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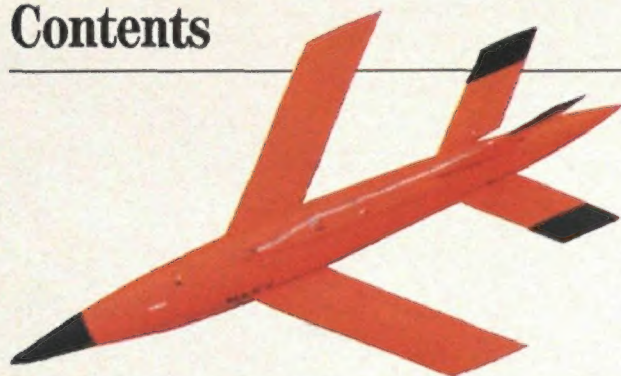


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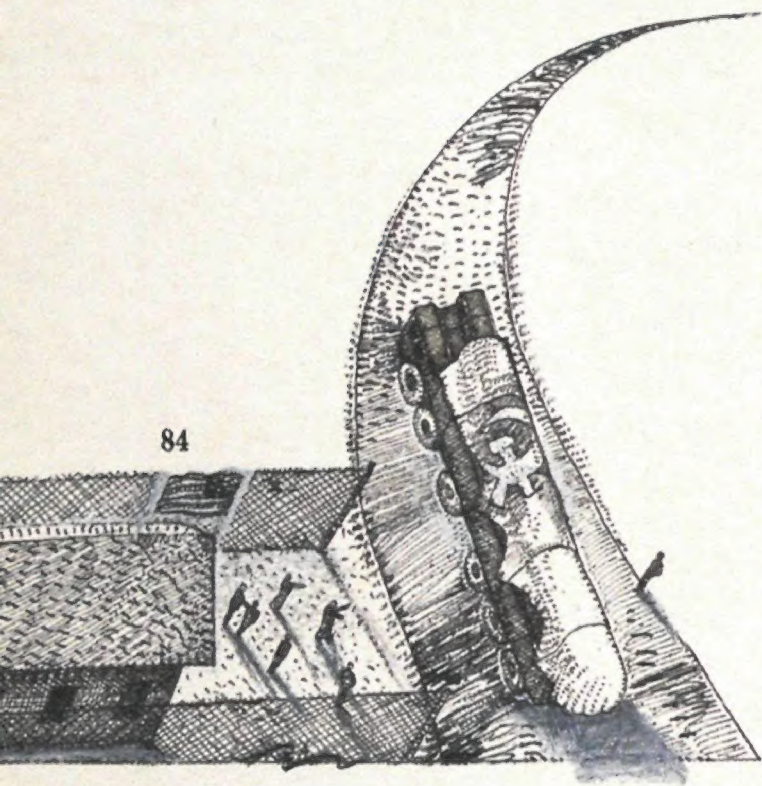
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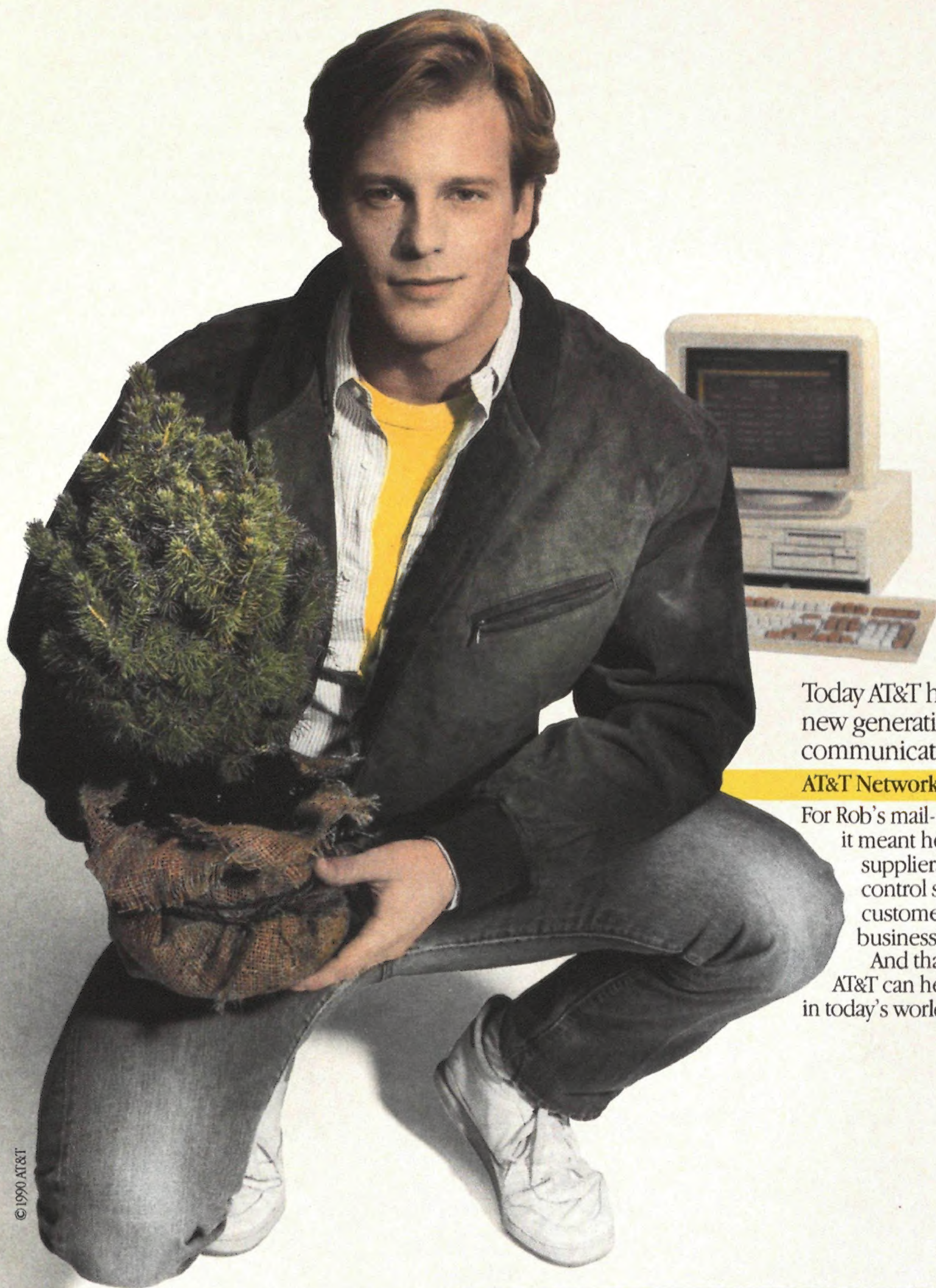
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From Qanats to Qantas

Everyone knows about Qantas. It's an Australian airline. But who has ever heard of qanats? The word isn't even in the dictionary. And yet, over the millennia, qanats have arguably had greater impact on the development of civilizations than aviation and spaceflight combined.

I first saw a qanat system in Turfan, a small town deep in the Gobi desert, thousands of miles from the nearest ocean but cradled in a depression below sea level. Wonderful vineyards flourish around the little town, and Turfan's delicious grapes are famous all over China.

This fertile region surrounded by hostile desert exists by virtue of an intricate system of subterranean canals—qanats. Qanats convey water across great stretches, with minimal evaporation along the way. Branches in the canals gather water from one or more mother wells at the base of a mountain and gently slope from there down to the town or fields where further branches distribute the water to where it is needed.

To build the canal, workers first dig a series of vertical shafts spaced every 50 to 150 yards along the entire route the canal is to follow. These shafts can be several hundred yards deep. They are needed to bring fresh air to workers digging connecting channels underground.

At Turfan, the qanat system channels water to the town from a towering mountain range roughly 20 miles to the north. But those 20 miles are deceptive. The actual extent of all the branches of this elaborate canal system runs into hundreds of miles.

Nobody quite knows where qanats originated, whether in China or in the Near East. They are most widely distributed in Iran. Paul Ward English of the University of Texas at Austin has estimated that over 37,000 qanats water more than one-third the total irrigated area in Iran, roughly 15 million acres all told.

Qanats appear to have come to Iran from the highlands of northern Iraq and eastern Turkey some 2,500 years ago, possibly in connection with early mining efforts undertaken in that region. Whatever the

origin of qanats, their use gradually spread to other arid regions all over the world, including northern Africa, Spain, parts of central Europe, the Canary Islands, and even Peru and Chile.


Though expensive to build and maintain, qanats were ubiquitous in the drylands of the Northern Hemisphere because they were the most economic means of water supply in regions where water is critically scarce. And without water, those areas could not have been populated.

In our time, airplanes, rockets, and spacecraft have similarly become ubiquitous because they provide rapid, often economical access to remote locations. We credit the Wright brothers with inventing the airplane, and many people forget that they were not the first men to fly. The first manned ascent preceded them by more than a century. In 1783, a balloon, the epoch-making invention of Jacques and Joseph Montgolfier, first carried a man aloft. More than a hundred years later, powered balloons—dirigibles—would be flown.

Buoyant flight still has its uses today: for recreational flying, for prolonged hovering above fixed locations, and for lifting scientific instruments to heights around 25 miles, at which neither airplanes nor spacecraft can long maintain altitude. But balloons and airships have become so rare that we crane our necks to get a better look when they fly by. Could they be on their way to extinction after not much more than two centuries?

Qanats may not be in the dictionary, and in time they may all be replaced by modern pipelines and then forgotten, but that should only make us wonder how long our own engineering triumphs, including high-performance aircraft and high-technology spacecraft, will be remembered. It doesn't seem possible to us now, but perhaps modern aviation and spaceflight also will prove ephemeral—here for a few centuries, only to be superseded by a successor technology and gone forever.

—Martin Harwit is the director of the National Air and Space Museum.

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Evidently, once you've looked beyond the obvious, it is difficult to see anything less.

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Letters

Not the Real McCoy

I thoroughly enjoyed David Noland's recollections of the Topps airplane cards (Oldies & Oddities, June/July 1990) and was delighted to see the MiG-19. In the late 1950s Aurora produced a plastic kit of that fictional airplane; it looked just like the illustration shown. In the manner of the time, a couple of foreign plastic kit manufacturers leased the Aurora molds and produced their own versions. A few years ago I made a trade—sight unseen—for a 1960s-vintage Soviet-made kit of the MiG-19, expecting, of course, the swept-wing fighter used in Vietnam. Typical of Soviet kits of that time, there was no box art and the only words I could read on the box were "MiG-19." When I opened it, I found a copy of the old Aurora MiG-19! Whoever drew up that first MiG-19 configuration surely never dreamed that the Soviet Union itself would produce and sell it as a scale model.

Wayne E. Moyer
Dayton, Ohio

Reunited

Your February/March 1989 issue had an article entitled "In the Land of Lost Bags" about the Unclaimed Baggage Center in Scottsboro, Alabama. The vice president of the company that runs the center, Bryan Owens, reported that no bag had ever been reunited with its owner. No bags perhaps, but we had a reunion with a NASA camera in 1987. One of our astronauts, returning from Africa with our training model of a Nikon F-3, lost his bag. I had heard of the baggage center on the news and wondered if we might find our camera there, but the inventory management people here at Johnson Space Center decided not to pursue it. Within two months a man from the Marshall Spaceflight Center inspector general's office called to tell me that he had received a call from a camera buff whom Owens had queried about the value of an unusual camera. Two hours later the Marshall employee called me from Scottsboro, where he and an FBI agent had

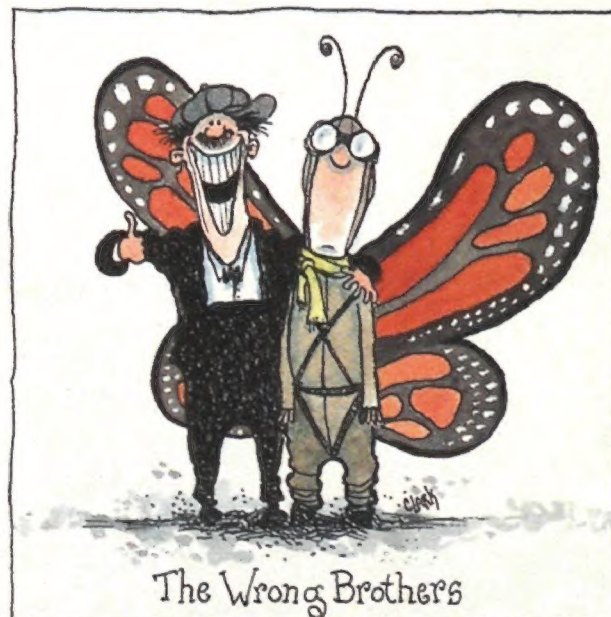
gone to retrieve the camera. The astronaut never had a "tearful reunion" with his suitcase, but we did get our camera back.

W.H. Bowers
Houston, Texas

The Last Word

Permit me to make a few remarks on the now-ragged question of whether to keep warbirds flying or relegate them to blocks and chocks ("The Battle Over Warbirds," April/May 1990). If you're a huge organization like the Air Force, the taxpayer pays the tab, but most of the warbirds now flying don't belong to big organizations. The whole thing began with a few guys who loved the warbirds and laid out just about every dime they had to buy and restore them. They put in their own time. They rebuilt what our government had thrown away. And none of us need the carping from the sidelines of all those people who didn't take their shot, didn't gamble their time, didn't sacrifice a new house or car or whatever to throw everything they had into warbirds.

In 1976 I shelled out over \$325,000 of some very hard-earned money to have a Ju-52 rebuilt. (There went my wife's new home, new car, jewelry, swimming pool, cruise to Europe, etc.) I flew the hell out of that machine for a total of 2,300 hours in



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the left seat. I flew airshows for 10 years and never took a dime when I flew for charity. With a few paid workers and a bunch of terrific volunteers, I took more than 2,000 people up for their first (and usually only) warbird flight. With my wife Dee Dee and our tightly knit crew, we performed before literally millions of people. It was all heady, marvelous stuff. It was *aviation*. So never forget, all of you out there trying to tell us what to do with the money we earn, the effort we expend, the chances we take, that *you* do not have the right to tell us what the hell to do. There are those who do, and those who make wind. Try performing instead of talking. It gets a lot more done.

Martin Caidin
Gainesville, Florida

Canning Pluto

"The Flying Crowbar" (April/May 1990) was quite well done, but it tends to fall into the familiar and overdone "How could the Pentagon have been so stupid?" syndrome. Yes, Project Pluto *was* a scary concept, but there are several essential considerations that younger readers and journalists do not appreciate concerning nuclear strategic weapons. The first is that the United States has them not to use but to deter their use. That concept, thank God, has worked rather well. Would Pluto be a deterrent? You bet. Would it have to undergo end-to-end flight tests? Not necessarily. Our intercontinental and submarine-launched ballistic missile forces have never been tested on realistic trajectories against hardened targets. Would Pluto be more of a danger to the launcher than the launchers? No—deployments, launch points, and trajectories could have been tailored to avoid such problems.

Pluto was canceled not because it was a dumb concept but because our then-planned triad of ICBMs, SLBMs, and manned bombers was judged to be more than adequate for deterrent purposes. The only essential difference between the "nightmare" of Pluto and today's offensive missiles is that current weapons do not use nuclear ramjet propulsion. All nuclear cruise missiles will be a continuing horror unless agreements can be reached for their reduction and eventual elimination.

Larry Soderberg
Broomfield, Colorado

Author Gregg Herken replies: I understand how you might feel that my article falls into the "stupid Pentagon" genre, but the opposite seems to me to be the case. The Department of Defense

abandoned Pluto once the advent of ballistic missiles, as you rightly point out, made supersonic low-altitude missiles unnecessary. The project was actually canceled by Secretary of the Air Force Harold Brown, who had previously been a director at the Livermore lab, Pluto's birthplace. But in canceling the project as unneeded, Brown in no way detracted from the accomplishment of Livermore's scientists and engineers, whose ingenuity in overcoming the obstacles in Pluto's path the article celebrates.

Is Anybody Listening?

In "Are We Running Out of Wars?" (Viewpoint, April/May 1990) Martin Harwit hit the nail on the head when he wrote that traditional wars are not likely to be our main threat in the years ahead. Instead, the damage we have inflicted on the environment poses far more serious challenges and potentially catastrophic problems for us and generations to come. I am glad someone important in Washington realizes this. Do you think he could mention this fact to the vice president and the members of Congress that are on the National Air and Space Museum board?

Jay C. Guy
Richmond, Virginia

It's Money That Matters

The essay "A Call for Quality" (June/July 1990) certainly rang my chimes, but I think one point should be stressed more forcefully. The chief executive officers for many aerospace companies in this country have been promoted from the accounting department, not the engineering department. Engineers dream, think, eat, and sleep hardware. Accountants crunch numbers and think about profits from last quarter, profits from this quarter, profits from here to eternity.

Pat King
Fallon, Nevada

Denver vs. Washington

I must take exception to the implied finality of the decision to locate the National Air and Space Museum extension at Dulles (Viewpoint, June/July 1990). While I support the need to expand, as a taxpayer and resident of the western part of the country, I feel that Denver's Stapleton airport offers a much better solution. The hangars are in place, the terminals are available for exhibits, the dry climate is more conducive

to preserving aging aircraft, and the central location would make the exhibits available to a larger portion of the U.S. population. Funding for this project is contingent upon approval by Congress, and in these times of deficit spending, the Museum needs to be pursuing those options that will give us the best dollar value instead of building a bureaucratic empire in and around Washington.

James Zavist
Denver, Colorado

Corrections

I really enjoyed the article on nose art ("Risqué Business" April/May 1990), but I believe I should make a correction while we oldtimers are still around. There never was a *Sweetie Pie Jones* or a *Sweetie Pie Jones II*. Just a plain ole *Sweetie Pie* and a *Sweetie Pie II*, which is a pet name for my son Jim Jones' mother.

Lieutenant Colonel Lem C. Jones
U.S. Air Force (Ret.)
Pilot of Sweetie Pie
Coushatta, Louisiana

On page 7 of the "Photos of Flight" supplement (June/July 1990) a caption reads, "Edward Vernon 'Eddie' Rickenbacker became an ace in his SPAD" Rickenbacker became an ace in a Nieuport, not a SPAD.

John H. Knibb Jr.
Hampton, Virginia

The "Artifacts" section of In the Museum (June/July 1990) states that an SR-71 began its record-setting flight from Los Angeles. The aircraft actually left the ground at Air Force plant no. 42 in Palmdale, California.

James E. McIlroy
Lancaster, California

Due to an editing error, "Slim Hennicke's Basement" (Collections June/July 1990) reported that Hennicke soloed an *Eaglerock* at Sheepshead Bay in eastern Long Island. Sheepshead Bay is in western Long Island, and Hennicke actually soloed at Riverhead, which is in eastern Long Island.

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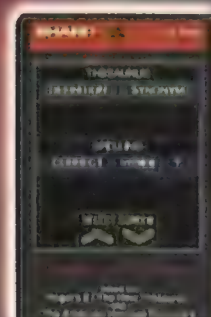
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Snow Job

DAVID CLARK



The Eskimos have a score of words to describe snow, and the conventioners at the International Aviation Snow Symposium can't be far behind. Held for four days last April, the 24th annual IASS brought together airport managers, maintenance supervisors, and plow drivers from the national snowbelt, with a dusting from Canada and Europe. After having convened for 20 years in Allentown, Pennsylvania, the group now meets, appropriately enough, in Buffalo, New York.

Giant styrofoam snowflakes hung in the lobby of the convention hotel, across the street from Greater Buffalo International

Airport. In the exhibitors' room manufacturers did their best to jazz up items like de-icer spreaders ("Airport Deicing Isn't What It Used To Be"), runway sweepers and de-rubberizers, snow brooms in myriad configurations, radiant floor heating systems, friction testers, tower lights, rescue vehicles, and something called a Ramp-Hog. There were color photos of the device showcased as "The World's Largest Snow Plow Blade" (32 feet, three inches long). Tufted plow brooms were advertised as being "smooth as a mule's nose." In a life-size cutout, a smiling model posed with one knee atop a

bucket of Permanent Asphalt Repair.

Given panels with titles like "Chemical Applications, New Regulations and the Environment" and "Results of the Tire Performance Evaluation Studies for Friction Testers," the symposium could get a bit deadly at times for a non-specialist. Still, the business of deciding how—or whether—to clear a runway or shut down an airport is a serious one, with thousands of travelers' schedules and safety hanging in the balance.

In his presentation on reasons to shut down an airport, Jerry FitzGerald of the New York-New Jersey Port Authority

judged that "the slush call is the most important." Unlike snow, slush on a runway can get sprayed into engines by an aircraft's nosegear and may cause engines to stall at critical speeds. The amount of slush an airport can handle, along with the state of taxiways, ramps, and snowblowers—not to mention the effectiveness of Murphy's Law—must all be considered. (As to deciding whether to let an airliner land in a snowstorm, FitzGerald suggested that one first determine if the aircraft is from Hawaiian Airlines or Air Canada and whether the pilot was born north or south of the Mason-Dixon line.)

Keeping nature tamed on the tarmac isn't just a point of pride. According to Colleen Quinn of the Air Transport Association, weather caused 58 percent of all airport delays last year, and a good chunk of those involved snow. Closing down runways at a large hub airport for a day, she says, can cost around \$650,000 in lost landing fees and operational delay costs.

The symposium wasn't all speeches and statistics. A chief attraction was the opportunity for fellow snow-movers to talk shop. There was a heavy-machinery driver training workshop, a trip to Niagara Falls, and, at the conclusion, the presentation of the five Bernt Balchen Awards. Named for the late Air Force colonel who was a crew member on the first flight over the South Pole in 1929 and who founded the symposium in 1966, the awards are given to five airports that exhibited grace under pressure during the past winter.

Holding the symposium in late April instead of, say, late January was surely a good idea. The weather was mostly sunny, in the 60s and 70s. The only ice in sight was in the drinks.

—Wes Eichenwald

RON MILLER



Voyager: The Soundtrack

New Age composer Michael Lee Thomas' latest album is truly out of this world. Entitled *Voyager—The Grand Tour Suite*, the Bainbridge Records release is a haunting composition based on the sounds of space transmitted by Voyager 2 during its 12-year tour of the outer planets. "I tried to create as much of a 'spatial' environment as I could—as much as I hate the word 'spatial,'" says Thomas.

The project got under way in the spring of 1989, when Randii Wessen, then the Voyager 2 Neptune science coordinator at NASA's Jet Propulsion Laboratory in Pasadena, California, was schmoozing with Bainbridge general manager P.J. Littleton. "They were all talking about the sounds that were coming back from space," says Thomas, "and P.J. said, 'Why not do something musical here?'" When Littleton called him, Thomas came up with the idea of a suite of songs that would serve as a "soundtrack" for the entire project.

The noise that Voyager 2 relayed to Earth was actually a series of electromagnetic disturbances created by planetary ring particles and clouds of charged particles in planetary magnetospheres. The signals were detected by the spacecraft's two plasma-wave antennas and converted to audible sounds at JPL. Thomas describes the results as "blips and bleeps that sort of sounded like R2D2 having a miserable day." After stripping out the extraneous noise and hiss, he fed the sounds into a synthesizer, which enabled him to build them into more elaborate forms, like the sounds of violins, drums, and piano. "It's a very long process," says Thomas. "It would take me 10 hours just to get five seconds of usable sound." He also incorporated recordings of the Voyager 2 launch, along with snippets of communications between NASA's tracking facility in Australia and the JPL mission operation center.

"We wanted to match the music to the discoveries," Thomas says. "It was fun to

compose motifs of what we thought Voyager heard as it sailed through the rings of Saturn or close to the volcanos on Jupiter's moon. I wanted to provide an emotional attachment to a piece of machinery so that listeners could close their eyes and imagine what happened out there."

A confessed "space weenie," Thomas has also created a promotional video to accompany *The Grand Tour Suite*. It's been shown on PBS and other TV stations and is now under consideration for scheduling at VH1, a music video station. "They have it," Thomas says, "but they're not quite sure yet what to do with it."

—Bruce Pilato

TOM HAMES, WORLD SPACE FOUNDATION



The World Space Foundation's solar sail is one of four designs selected as entries from the Americas in a proposed 1992 race to Mars. Huge solar sails, designed to be propelled by the pressure of photons of light bouncing off their vast reflective surfaces, would travel as fast as chemically propelled spacecraft but be extremely lightweight. Canada, Great Britain, Italy, China, and the Soviet Union will also participate in the one-to five-year race.

Update

Piaggio Gets FAA Approval

The P.180 Avanti twin-engine turboprop received the Federal Aviation Administration's basic type certificate last May ("Piaggio," August/September 1988). Company officials expect the aircraft will receive complete type certification late this summer. Delivery of six of the 460-mph, \$4.13 million business aircraft is slated for the end of this year.

Traffic Lights

On April 19, at a brief ceremony in a hangar at Washington, D.C.'s National Airport, a Federal Aviation Administration official presented USAir's Patricia Goldman with agency certification for a new kind of airline safety system called TCAS (pronounced TEE-cass), for Traffic Alert and Collision Avoidance System. Goldman, the airline's senior vice president for corporate communications, used to serve on the National Transportation Safety Board, which has for years pressed for incorporation of a collision avoidance system on airliners.

Recent FAA regulations mandate that all airliners carrying 30 passengers or more be equipped with TCAS by 1993. With the system, pilots will know where their traffic is when it is well beyond visual range, and will no longer have to rely entirely on air traffic controllers to warn them about it.

Parked in the hangar at National was a spanking new USAir Boeing 737-400 equipped with the very first system, and after the speeches, the audience was invited aboard for a demonstration drive. A camera had been installed in the cockpit, and monitors were located in the cabin ceiling along the aisle so we passengers could watch the TCAS display.

Tommy Littlejohn, a pilot employed by Bendix/King, the avionics company that made the TCAS we'd be using, would fly his company's Sabreliner business jet through maneuvers simulating typical encounters that airliners experience, including head-on passes. The hangar door opened, a tug was hooked up, and finally the

Boeing was towed outside for engine start.

The monitors lit up, and over the cabin speakers a cockpit crew member wished us all a good morning. The TCAS display—a small video screen in the instrument panel—appeared on the monitors. Little white diamonds were moving around the screen, at the center of which was an airplane symbol that represented us. The pilot explained that as traffic flew closer to us, the symbol changed to a filled diamond, then a yellow circle, and finally, when a collision looked imminent, a red square. A yellow circle was also accompanied by a voice saying "Traffic, traffic." The red square's voice was more demanding: "Conflict—climb, climb" or "Dive, dive," depending upon the situation.

The airliner took off with Littlejohn following in his Sabreliner, and when we reached a point over the Shenandoah Valley, the Sabreliner briefly flew in formation with us off our right wing. People scrambled to the windows to watch it. Then the Sabreliner broke off and flew out of sight to start some near-collision courses.

It was clear as a bell that day, which helped to bring home a point: pilots of jets can't see each other until they're so close that their combined speeds make avoidance maneuvers rather frantic. But each time Littlejohn closed with the 737, we could see the little symbol representing his Sabreliner as it crept across the video monitor until, when he was only seconds away, we could see him out the window.

Amid all the excitement, USAir even served lunch. I counted five near-collisions in the course of just one tuna fish sandwich.

—George C. Larson

Update

Orbital Maneuverer Axed

Citing budget cutbacks, NASA has canceled its \$736 million Orbital Maneuvering Vehicle program with TRW (Soundings, August/September 1989). The remote-controlled "space tug" was designed to boost the Hubble telescope and an X-ray astrophysics satellite to higher orbits. The agency has asked TRW and Martin Marietta to study the feasibility of building a satellite servicer that would combine the capabilities of TRW's OMV and Martin Marietta's Flight Telerobotic Servicer ("Invasion of the Spacebots," February/March 1990).

Weightlifters

Aero Design '90, a competition for aeronautical engineering students held last May at Douglas Aircraft in Long Beach, California, was a sort of skunkworks with training wheels. Sponsored by the Society of Automotive Engineers and hosted by McDonnell Douglas, the exercise challenged U.S. and Canadian students from 35 universities to build radio-controlled model aircraft with standard engines and generous amounts of wing area that could carry as much weight as possible. Each entry had to fly off a 200-foot runway, circle, and land on the same runway, all the while carrying a minimum of eight pounds of lead bars. First prize would go to the model carrying the biggest load.

The models bespoke a number of design philosophies. Some represented the by-the-book school of design: read a stack of textbooks and wind up with something that resembles a heavy-duty *Spirit of St. Louis*. Bolder models, however, took innovative approaches in the design, materials, and intuitive flight categories.

The design students were true philosopher-kings of flight, like the team from Parks College of St. Louis University. They consulted all the right texts, huddled with professors, and were told flat-out that their ideas would never fly. They went ahead anyway, and after much mathematical plotting and wind tunnel work built a canard-wing entry that represented a real breakthrough in high lift factors. But typical of flight philosophers everywhere, the Parks College students were still

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Separated at Rollout?

LEE BATTAGLIA (2)



The F-117A Stealth Fighter . . . and Darth Vader? (with apologies to *Spy* magazine)

building their model when the contest began, and it only really got airborne once.

The materials freaks were represented by the University of Central Florida team, who bypassed the usual foam-and-fiberglass surfboard technology and plunged straight into Kevlar and carbon fiber. They even had an MTV-quality video to accompany their presentation. Heaven only knows what the students from Ontario's Queens University were thinking: they entered the

competition with no aircraft construction experience whatsoever and ended up with something apparently constructed from the contents of a kitchen junk drawer.

The intuitive flight group believed in flying, not thinking. The team from Iowa State University had worked with sailplanes and built a cross between a Blériot monoplane and a box kite. The students from Calgary's Southern Alberta Institute of Technology didn't quite know

what would work. Since they were good mechanics they just built, crashed, and fixed airplanes until they had a *Spirit*-like model that flew.

At the end of the three-day competition, the flying area was littered with fragments of balsawood and fiberglass—indeed, the area should have had a “hard hats only” policy to protect people from the overloaded aircraft dropping out of the sky. Ultimately, the *Maple Leaf II* from the University of Saskatchewan won, carrying 22.25 pounds, while the University of Oklahoma at Norman triumphed in the design competition.

—Michael Jordan

Going, Going . . .

Initially, all eyes were riveted on the gleaming silver P-38 that had been rolled up to the tent—it was one of just six flyable Lightnings in the world and the centerpiece of last May's Classic Aircraft and Memorabilia Auction at the Museum of Flying in Santa Monica, California. But as the bidding soared past seven figures, the airplane was all but forgotten as attention

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GOING IN HOT by William S. Phillips

shifted to the two people trying to buy it.

In one corner was retired Air Force Major General William Lyon, a former P-38 pilot who now owns Martin Aviation. In the other was an anonymous bidder—or rather, the telephone through which his bids were relayed. As the price climbed higher, the atmosphere went from mildly charged to highly electrified. “This is crazy!” somebody yelled.

Lyon and his unseen rival traded bids like boxers exchanging punches—\$1.3 million, \$1.4, \$1.5. Then Lyon made a final offer of \$1.55 million. “The aircraft is here today. The aircraft is selling,” the auctioneer prodded. “Are you all through at one million, five hundred and fifty thousand?” He waited several tense seconds, but silence prevailed. When he shouted “Sold!” the crowd went berserk.

The sale of the P-38 marked the emotional—and financial—high point of the auction, but nearly 70 historic aircraft crossed the auction block during the two-day affair. So did thousands of pieces of aviation memorabilia, ranging from models of proposed jet bombers to Jimmy Doolittle’s 34th Fighter Squadron cap. The total take was more than \$7 million.

The auction was sponsored by the Museum of Flying, which opened last year at Santa Monica Airport. Museum director Don Madonna would like to see the auction become an annual event. “Our long-term objective,” says the former Air Force test pilot, “is to be for classic and vintage airplanes what Christie’s and Sotheby’s are for other collectibles.”

Though Madonna had been hoping for more World War II aircraft, the roster was still impressive. In addition to the P-38, there was a Spitfire Mark IX, a Hawker Sea Fury, a P-40K Warhawk, a TBM-3E Avenger, Hap Arnold’s B-25, four P-51 Mustangs, and, representing a more recent era, a candy-apple red Gnat formerly flown by the Royal Air Force Red Arrows. On the civilian side, there was a trio of trimotors, a 1909 Blériot, United’s first DC-3A, and a JN-4 Jenny restored right down to the wicker seats.

“It’s probably the best single collection of any auction I’ve ever been to,” said Bob Waltrip, founder of the Lone Star Flight Museum in Houston. Waltrip picked up a bright yellow Beechcraft T-34A for \$225,000 and considered it a bargain. After all, one bidder paid \$725,000 for an FG-1D Corsair that wasn’t even at the auction.

For aviation enthusiasts, there were World War II fighters roaring overhead. For people watchers, there was a tent filled with Hollywood luminaries like Cliff Robertson, Goldie Hawn, Kurt Russell, and Bruce Boxleitner. The open bar and trendy

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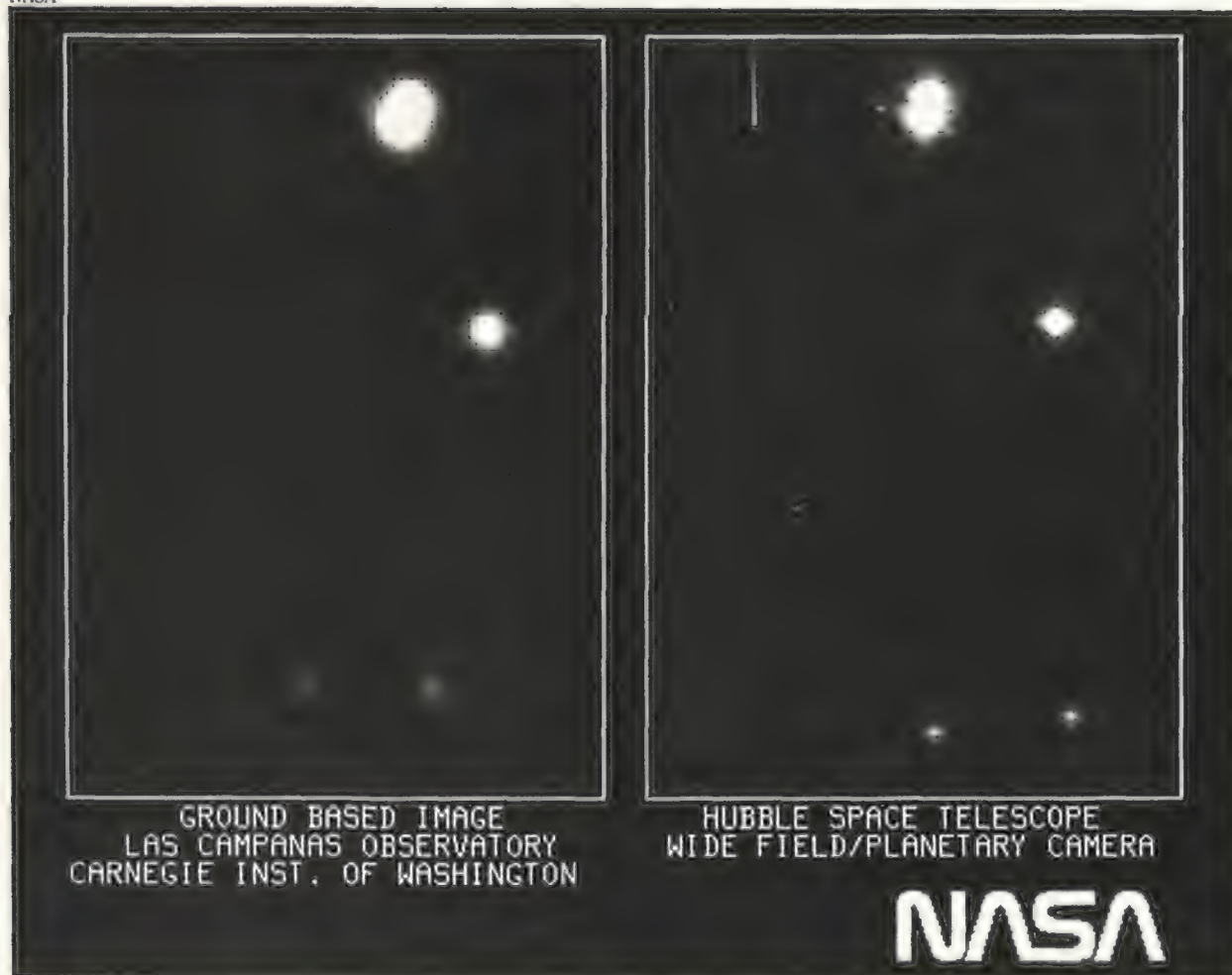
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food were provided by some of the area's finer restaurants. Of course all this entertainment didn't come cheap: tickets were \$250. Complained one disgruntled patron: "Outrageous! Even the models were selling for \$300 and \$400."

—Preston Lerner

The Scope of the News

It was late in the morning on Sunday, May 20, when the Hubble Space Telescope saw what astronomers call "first light"—literally the first starlight to fall on the instrument's massive primary mirror, secondary mirror, and sensor packages. That afternoon, NASA hosted a press conference at the Goddard Space Flight Center in Greenbelt, Maryland, where those first images were expected to arrive.

The parking lot was half filled with cars and vans. Some large converted motor homes were snuggled up against the Visitor's Center, and sprouting from their flanks were tall, telescoping towers topped with microwave link antennas pointed like cupped ears toward downtown Washington. Cables lay everywhere.

Until then, most news stories about the Hubble made heavy use of descriptors like "troubled" in reporting the deployment of the huge \$1.5 billion space telescope, and many of those stories, darkly implying that, yup, another fiasco is in the works, made page one. Late-night comedians had a field day with the subject; David Letterman devoted a "Top 10" list to excuses why the telescope wasn't working (number 4: "Those damn raccoons!").

There were some problems—two

antennas wouldn't swivel fully when they ran afoul of a cable, and the whole system occasionally got a case of the nerves and shut down into a "safe" mode to protect its sensors in the event of a malfunction. But by the weekend the huge spacecraft seemed to be settling down like a new infant.

At the appointed hour, a panel of NASA officials assembled in the press room before a bank of cameras and a few rows of journalists. The centerpiece of the room was a large-screen monitor that would show the first images captured by the Hubble's primary sensor, the Wide Field/Planetary Camera.

Finally, the camera's designer and supervisor, James Westphal of the California Institute of Technology in Pasadena, appeared on the screen. An avuncular man with white hair and a manner like a department store Santa, Westphal patiently explained in lay terms what was going on as his assistants manipulated the electronic representation of the target star group—NGC 3532—on a small computer workstation. Then the screen went blank, and the assemblage saw some white streaks on a gray background. There was a long silence, and the faces of the officials on the panel turned stony.

For several long minutes Westphal kept chattering about what he and his elves were up to, and then suddenly there was a star. The mood in the room switched gears.

Westphal explained that this was, indeed, a star, and that it was quite a good image of one—better, in fact, than they'd expected. Then, without warning, the screen blinked again, and there was a sharp, clear image of

four bright points of light, one of which looked like two points that had merged—a double star.

Westphal's technicians rattled their computer keyboards and the screen switched again, this time comparing an image of the same star group as recorded by a telescope in Chile. Hubble's first faint image, without the fine tuning, was already vastly superior to one of the best a ground instrument could manage. The reporters burst into applause.

Then Westphal entered the room, which instantly became brighter than it had been under the TV lights. He used words like "pleased as punch" and "fun" and grinned from ear to ear. He had a right—he'd been waiting 13 years for this moment.

Although Westphal tried to play down the double star as a "discovery"—an oblong image from the Chilean telescope had already suggested a double configuration—most journalists resisted any demurral on that point. They wanted "discovery," so discovery it would be.

But by late June, focusing difficulties led to the startling revelation that the Hubble's optics are flawed and that much of its work will have to be put on hold until a repair mission can be made. At least the space telescope was back on page one.

—George C. Larson

ICBM Rally

It was something like a cross between an old-style high school pep rally and a scene from *Dr. Strangelove*. The backdrop was the auditorium at Vandenberg Air Force Base in Southern California, where last May six U.S. intercontinental ballistic missile crews met to thrash out which among them was the best, the fastest, and the most efficient.

The ethos of "duty, honor, country" has bred in these workers a tradition of straightforwardness reminiscent of the days of Andy Hardy. The 15th Air Force Band was playing college fight songs. The missile crews had given themselves names like the Bandits, Rough Riders, and Warriors of the North. Leading their cheers were a cowboy brandishing a six-gun, an Indian brave with headdress and painted face, and a Viking chieftain with sword and horned helmet.

It was the final night of Olympic Arena, an annual event that pits crews against one another in the quest for a trophy. For three days the teams competed in welding, marksmanship, capturing would-be terrorists, preparing missiles for launch, and similar chores that fill their days and nights on duty. Last year the Muleskinners of Missouri's Whiteman Air Force Base

beat Montana's High Plains Warriors from Malmstrom AFB by a single point. This year both teams were back, led by the same commanders.

Those who live with the missiles are the military equivalent of the Maytag repairman. Aircrews can fly practice missions, sailors can ship out, the Army can run maneuvers with tanks, but nuclear-tipped Peacekeeper and Minuteman missiles cannot be fired in training exercises, and launching dummy missiles would damage the silos. So the weapons sit in their silos, in Missouri, Montana, Wyoming, and the Dakotas, and the crews sit with them.

More cheers arose as the last day's scores in the various categories were posted on a board at the back of the stage. Malmstrom pulled out in front, but three other bases were close behind. Then Whiteman racked up a big score in Maintenance. With the final scores about to be posted, Colonel Edward Burchfield, Malmstrom commander, looked across the audience at Colonel Tom Kuenning, his counterpart at Whiteman. "Here we are again," he said. When Malmstrom won by 13 points, blue-jacketed Malmstrom staffers swarmed onto the stage, carrying a banner that read GOTCHA!

Olympic Arena, says Burchfield, "is one of the few times when they can see that score go up as a product of their work. The spirit bursts loose, a spirit you can't capture until you're a part of it." What helps elicit this enthusiasm, perhaps, is that the missile crews are getting very good at reducing World War III to a series of exercises in civil engineering, security, maintenance, and communications.

—Tom Heppenheimer

Update

Dash 80 Restoration

Boeing's first 707 is back home in Seattle undergoing intensive care after spending 18 years baking in the Arizona desert ("Dash 80," April/May 1987). Boeing technicians are restoring the aircraft's exterior for a 1991 celebration of the company's 75th anniversary. Dash 80, which belongs to the Smithsonian, will move to the National Air and Space Museum Annex at Washington-Dulles International Airport when that facility is completed.

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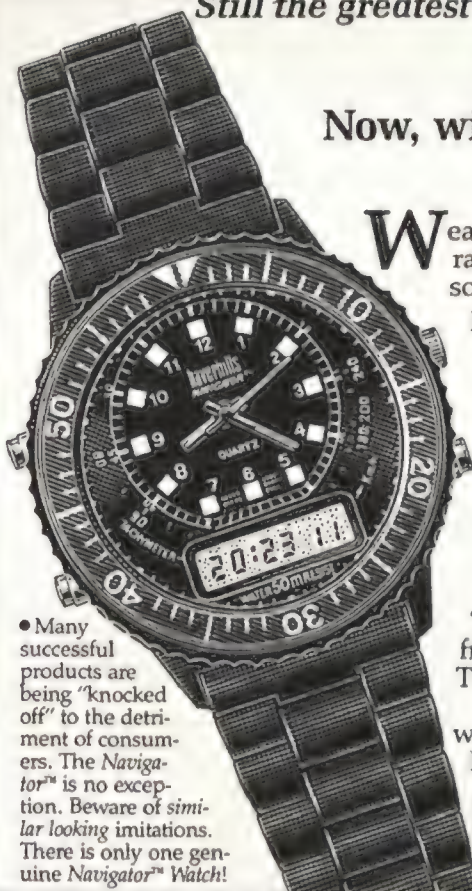
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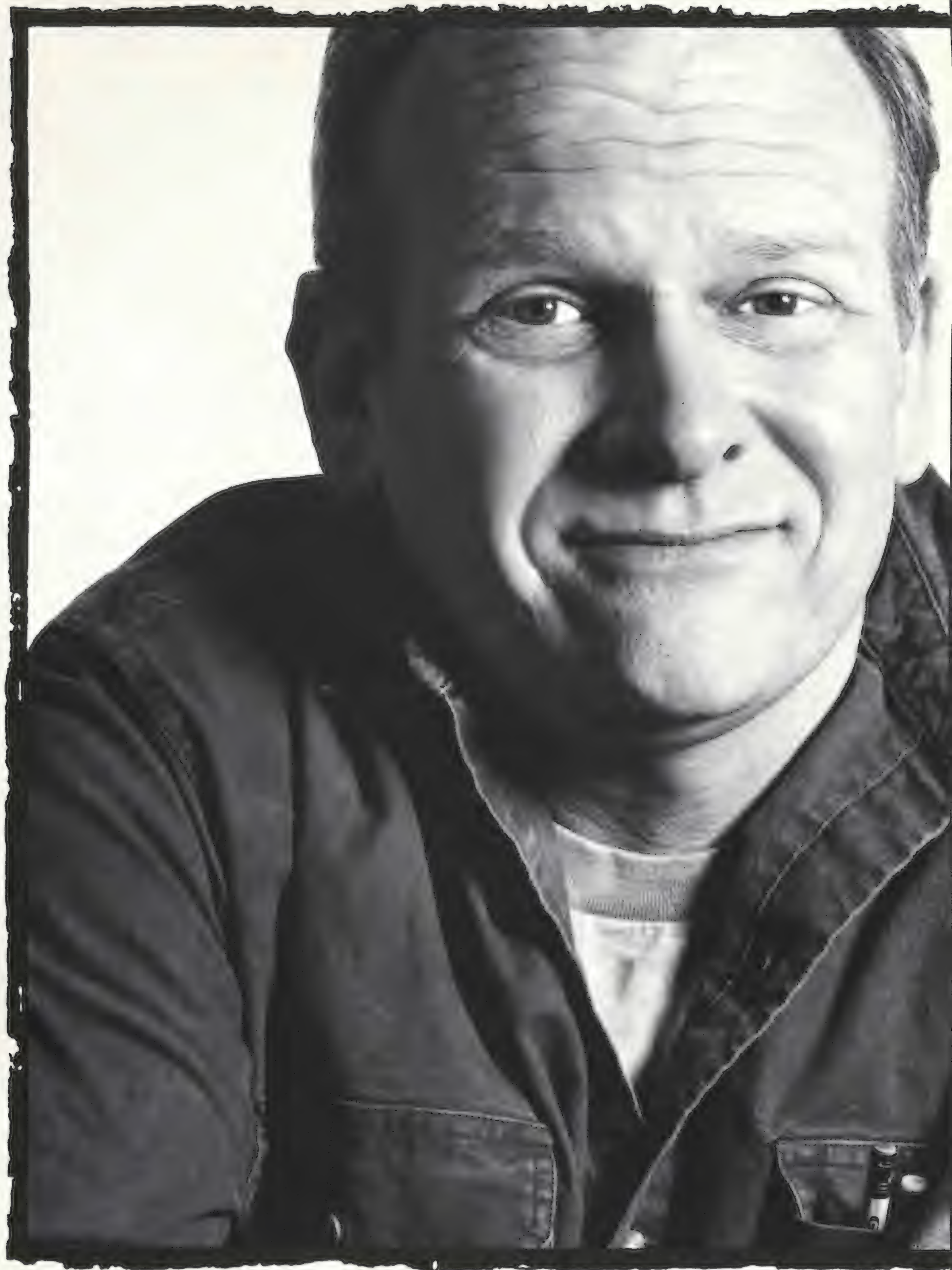
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In the Museum

Shipbuilding

Tailhook poised to grab a wire, a KA-6 Intruder tanker lunges toward the aircraft carrier. On the ship's busy flight deck, F-14 Tomcats await launch, crew members ready EA-6B Prowlers, and tractors service A-4 Skyhawks.

All this action takes place inside a large glass display case near the entrance to the National Air and Space Museum's Sea-Air Operations Gallery. Inside the case is a 1:100 scale model of the world's first nuclear-powered aircraft carrier, the USS *Enterprise*. From bow to stern the 250-pound model measures just over 11 feet. Its flight deck is two and a half feet across, and from keel to mast the ship stands two and a half feet tall. The ship was made completely from scratch, with no manufactured parts.

The model's wealth of detail is obvious to even the most casual observer, but few ever notice the miniature Porsche 911 parked below in the hangar deck. It is, in effect, the signature of Steve Henninger, who spent 12 years building the model. A

test engineer for the Gamma Ray Observatory at the Kennedy Space Center in Florida, Henninger was recently invited by the Museum to rearrange the model's flight deck. Instead of catapulting F-14s off its bow, the *Enterprise* now portrays the arrival of the KA-6.

Henninger constructed the model while he was working at satellite tracking stations in Wallops Island, Virginia, Arequipa, Peru, and Johannesburg, South Africa. Relying on *Jane's Fighting Ships* and photographs from *Aviation Week* and *National Geographic*, he built the stern first, followed by the flight and hangar decks, and the bow section. He also acquired declassified cross-sectional plans from the Newport News Shipbuilding and Drydock Company. Henninger says the biggest challenge is always building the hull. "My philosophy is if you don't have a bottom, you don't have a ship."

While he worked on the hull, Henninger hopscotched back and forth from the ship to



"I was never in the Navy so I had a lot to learn," says Steve Henninger.

The Museum's *Enterprise* features a fleet of 83 aircraft.

CAROLINE SHEEN (2)



its aircraft. "When I got sick of one," he says, "I'd go to the other." Building the RA-5 Vigilantes and E-2 Hawkeyes from scratch proved to be challenging. Each Hawkeye required about 200 hours' work.

Henninger also had the opportunity to make two reconnaissance trips to the real *Enterprise*. In 1975 he flew to Singapore and spent five days sailing toward the Philippines. The model represents the configuration of his 1975 visit. "The Navy was extremely helpful and basically opened the ship up for photography as long as I didn't go into the combat information center and take pictures there," says Henninger.

By the time Henninger returned stateside in 1976, the model had progressed to the point that he needed a U-Haul to transport it to Boulder, Colorado, where he applied the finishing touches. In August 1982 Henninger and his brother loaded the model into a truck and drove it cross-country to the Museum. It was dedicated on August 20, in a ceremony attended by three former commanding officers of the real *Enterprise*.

After working a thousand hours a year for 12 years, finishing the model was a

reward in itself. But there have been others, including an invitation back aboard the *Enterprise*. "It was grand," he says. "I actually took the helm of the ship for half an hour. I got a kick out of that. Kind of like a kid sitting in a fire engine."

It Came From Outer Space

The Museum's moonrock may have to make room for a new kid in town—a Martian rock. Actually, it's the main attraction of a new exhibit called "A Piece of Mars?" located in the Exploring the Planets gallery.

The question mark is significant. The Museum's moonrock, which was chauffeured back to Earth by the Apollo 17 astronauts, is undoubtedly from the moon. The rock on exhibit in Exploring the Planets arrived on our planet under far different circumstances. It crashed to Earth as a meteorite and may have been ejected from Mars when a comet or an asteroid collided with the Red Planet perhaps some 180 million years ago.

"It's not really a very dramatic looking rock," says the Museum's Steven Soter, "but it is extraordinary when you understand what it is." About two inches in diameter, the grayish rock has a fusion crust that was created after the outer skin melted as it entered our atmosphere. A cut section of the rock also reveals tiny glass nodules. These nodules contain trapped gases that almost exactly match the composition of the Martian atmosphere, which was determined by the Viking 1 and 2 landers in 1976. Neither the Viking probes nor any other spacecraft sent to Mars have brought rock samples back to Earth, making the Museum's specimen all the more extraordinary.

The rock is a fragment of one of eight meteorite falls collected from locations around the world and classified as shergottites, nakhlites, and chassignites—or SNC (pronounced "snick") meteorites. This particular fragment of shergottite was discovered in Antarctica in 1979. Because its ice cover makes discovery relatively easy, Antarctica has been a rich hunting ground for meteorites. Also helpful is the action of glaciers in herding samples in one direction, concentrating them in places where their flow is obstructed.

If the Museum's rock is really from Mars, the implications are enormous. The sample was found to contain significant amounts of complex organic molecules, the chemical building blocks of life. "This does not mean that there is life on Mars," says Soter, "but it does allow the possibility that there was life in the past."

—David Savold

Artifacts



Although they are more commonly known by a variety of less polite terms, the official name for these bags is "motion discomfort containers." The Museum doesn't actively collect them, but it does have about 150 bags in storage at the Paul E. Garber Facility in Maryland. Most have been donated over the years or were picked up by curators flying on lesser known airlines. Their function is always the same, but their designs are often different. While most bags feature the name of the airline, some feature games or crossword puzzles. One bag could even be used for getting film developed.

Museum Calendar

Except where noted, no tickets or reservations are required. Call Smithsonian Information at (202) 357-2700 for details.

Smithsonian Resident Associate Program's Silver Anniversary

"Infinite Illusions," a symposium on computer graphics. September 7-16 at the Ripley Center. Anniversary gala begins September 22 in Baird Auditorium of the National Museum of Natural History.

New Films Two IMAX films, *Race the Wind* and *Freedom to Move*, are now shown Fridays through Sundays at 8:30 p.m. Admission: \$4 adults; \$2.50 children, students, and senior citizens.

August 4 Monthly Sky Lecture: "Navigating the Skies." Jim Sharp, NASM. Einstein Planetarium, 7:30 p.m.

September 6 Legacy of Strategic Bombing Symposium: "The Strategic Bombing Surveys." Participants include George Ball, John Kenneth Galbraith, Paul

Nitze, Ramsay Potts, and Lord Solly Zuckerman. Langley Theater, 8:00 p.m.

September 28 Legacy of Strategic Bombing Film: *Dr. Strangelove*. Langley Theater, 8 p.m.

Planning a Smithsonian Visit?

The Associates' Planning Packet is yours for the asking. Send a postcard to Associates' Reception Center, Smithsonian Institution, Washington, DC 20560, or call (202) 357-2700. Hearing-impaired visitors can use TDD and call (202) 357-1729. Begin your visit at the Associates' Reception Desk, located in the Smithsonian Castle.

Museum Hours Throughout the summer, most Smithsonian museums will be open 10 a.m. to 5:30 p.m. daily. The Smithsonian Castle, which has reopened with the new Smithsonian Information Center and Associates' Lounge, is open 9 a.m. to 5:30 p.m. daily.

Lights, Camera, History!

Columns of black smoke rose from a hangar to my right, then blanketed the airfield. The ground rocked as explosions sent chunks of dirt and cement raining over the Spitfires parked near the runway. My hands moved reflexively to the two Nikons hanging against my chest.

Two Spitfires had taken direct hits, and as their molded fiberglass shells burned they gave off an ugly, acrid smell, making it difficult to breathe. Three German Heinkel bombers made another run over the field. Above them, two Spitfires banked and dove in what appeared to be a life-and-death contest with a trio of Messerschmitts.

I braced for more explosions, but there were none. Instead, all the airplanes, friend and foe alike, fell into a graceful formation and descended to the small airstrip.

It felt like 1940, but this was really 1968. I was watching a crew making *The Battle of Britain*, a movie about the great air battle that became Germany's first major defeat of World War II. My assignment was to photograph the United Artists production at Duxford Airfield, an abandoned Royal Air Force base in

Cambridgeshire, England.

As in a real war, not all was going according to schedule. Each scene had to be rehearsed repeatedly. Fuses blew and wiring shorted, so the charges set to blow up buildings and runways just as the German airplanes flew over often failed.

The weather was against us too. A low overcast made it difficult to shoot anything that combined action in the sky and on the ground, and filming was delayed for days at a time. The production staff and I were restless, but others were delighted. The young pilots—some British and some Spanish, most younger than the airplanes they flew—were getting paid to sit in the canteen and swap stories. Once in a while the film's stars—Robert Shaw, Susannah York, and Christopher Plummer—would drop by for a scotch or pink gin and stay to listen. Another guest was Group Captain Peter Townsend, a hero of the real Battle of Britain who was then romantically linked to Princess Margaret. Prince Charles also paid a visit.

Some of the aviators tried to appear blasé in the presence of the stars. But,

when pilots from the real Battle of Britain stopped by, they fell all over themselves. Most impressive was Sir Douglas Bader, who shot down 23 enemy airplanes, even though he had two artificial legs.

Such visits were rare, though. And as the delays mounted, everyone grew fidgety. For me, what was to have been a week's assignment had stretched to three.

Finally the forecasters predicted a near-perfect day for Essex and Kent. There would be scattered clouds at 8,000 feet, just what the director had been praying for. Heinkel bombers with a cover of Messerschmitts were to fly above the clouds. They would be intercepted by Spitfires and Hurricanes, which would punch through the clouds and engage the enemy at the director's command. The rest was to be celluloid history.

Some of the movie cameramen were flying in Messerschmitts equipped with plexiglass gondolas under the fuselage; other cameras were on the Heinkels. But the main cameras were in the nose and by the windows of a converted B-25 Mitchell bomber that had been painted a patchwork of vivid colors and patterns to ensure that other airplanes would keep a safe distance.

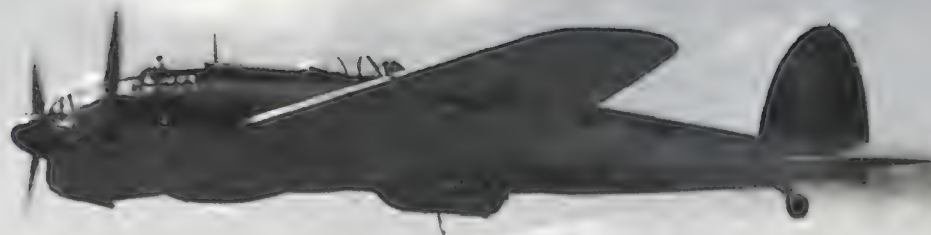
The B-25 had a couple of nooks for still photographers, one of which had been reserved for me. I was awaiting boarding instructions when I saw the airplane pulling away from the hangar. I didn't have a chance to get the pilot's attention before the airplane was rolling down the runway and taking off. I had waited 10 days for this moment and there I was—grounded.

All around me, dozens of people milled about in confusion. Some were in German uniforms, others in British flight suits. Some wore the label "Poland" at the top of their sleeves. Still others wore the uniforms of the Free French.

Finally I spotted a man in a white turtleneck sweater. He was carrying a red megaphone, a sure sign that he was someone important. I told him how the camera platform had left without me. He responded with one word: "Insurance." I had no idea what he meant, but he said it with such authority that I knew I'd heard

In 1968 the Battle of Britain was re-created at Duxford Airfield in Cambridgeshire.





the last word on the subject. I was wondering how I was going to explain this one to my client when the megaphone man turned to me and asked if I could run to get on the last of the Heinkels before it took off.

The airplane was taxiing toward the runway a hundred feet away. I began to run to it, the Nikons bouncing against my chest and a heavy camera bag bumping at my side. Suddenly the man with the megaphone shouted, "Get back! Get back!"

I turned and saw him pointing to his shoulder. "You must wear a parachute," he yelled. Fortunately there was one handy. I placed my cameras and bag on the ground and accepted help wriggling into the harness. I had some difficulty getting the cameras back around my neck, but, with assistance, I managed.

The airplane had stopped at the end of the runway, smoke spewing from its two engines as it prepared to take off. I waved to the pilot. He appeared to be waiting for me—at least he wasn't moving down the runway yet. Lumbering like a bear, I reached the airplane. The pilot signaled me to go underneath. Carefully avoiding the spinning propellers, I reached the belly. Now, how to get in?

There were no signs saying "Enter here." I tried a few handles. Nothing moved. Crouching, almost crawling beneath the airplane, I found a handle and pulled it. Eureka! I found the hatch.



Battle of Britain pilot Peter Townsend paid a visit to the film set.

I tried to climb in, only to discover that the opening was too small to accommodate me, the parachute, the cameras, and the bag. I threw the equipment into the airplane, then disengaged the harness and tossed the parachute inside as well. At that point I heard the engines speed up. The airplane began to taxi while I was only halfway in, with my feet dangling outside!

For a moment I wondered if photography was the only way I could earn a living. As the airplane lifted off I cursed both Daguerre and the Wright brothers for their diabolical contraptions.

When the airplane abruptly banked 60 degrees to the right, the cameras and bag tumbled away from the hatch opening.

They were safe, at least. I had managed to pull myself inside, but I was still astride the open hatch, the ground receding beneath me, G-forces pushing me downward.

With my left hand I grabbed something solid. I crouched down to reach the hatch's handle with my right hand but I couldn't reach it. I crouched lower and grabbed it. It wouldn't budge. Cautiously I looked down. Through my legs I could see the English countryside whizzing by before we entered a cloud bank. Then there was only the roar of the engines as the wind flapped furiously at my trousers.

A few seconds later we were above the clouds. Through a side window I saw a Spitfire coming directly at us, strobe lights flashing to simulate machine gun fire. For a moment I wanted to shout, "I'm on your side!" but I had other problems.

The Heinkel banked once again. On cue, black smoke began to stream from the wing as the airplane went into a steep dive.

I resolved not to become World War II's very last casualty. Once the airplane leveled off, I tried again to close the hatch. Almost blinded by the smoke that had entered the airplane, I got hold of the handle once more

The smoke was canned and this Heinkel 111 carried cameras, not bombs.

and pulled. Still nothing. The parachute was in the way. Carefully I twisted around to remove it. A push here, a pull there, and suddenly it gave way, enveloping me in waves of white silk.

My feet were still astride the open hatch. Now I was more afraid than ever to move for fear that the parachute would be sucked out of the opening and take me with it. I resolved to stay put for the duration of the flight.

Eventually we landed. As I emerged from my silken cocoon and gratefully

Stars like Kenneth More and Susannah York were upstaged by the real heroes.



jumped to the ground, I met the pilot. "¿Tomó usted algunas fotografías buenas?" he asked me.

"Sí," I answered. "I got a lot of good photographs." It was my secret and I didn't care to share it.

—Lee Battaglia

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Up Over Down Under



"I hate to tell you," the missionary said, raising his voice above the drone of the single-engine Cessna, "but you've lined us up on a cloud shadow."

Deferring to the cloth, I stifled an expletive and saw that the dark hill I had been aiming at was indeed a drifting cloud shadow and that I had slid a degree off course. Our target was an aboriginal settlement some 150 miles south of Alice Springs, in the very center of Australia. With no radio navigational aids to lean on, we had to aim at some bump on the barren horizon, a crag or hill that was *exactly* on the correct compass heading. A one-degree error would send us droning toward oblivion over an enormous, empty landscape where navigation aids of any kind were few and far between.

Even to most Australians, the Outback—the continent's beautiful and brutal heartland—is exotic. Much of it is blank desert, like the Simpson that now stretched southeast of us. Behind us was "the Alice"—Alice Springs—which had the only large airport for hundreds of miles. Any fool could tune in to its beacon and find the Alice. But only a fool, I decided, would leave it behind to search the Outback for an earthen airstrip with no radio or beacon to call out its presence.

A fool or an Outback pilot. The missionary beside me did it routinely. Yesterday I'd flown with him to a distant ranch—a simple flight, since the southwesterly course from the Alice took us between the unmistakable monoliths of Ayers Rock and the Olgas. But then we'd picked up a ranch owner who wanted to get home, and the directions to his spread revealed the awesome casualness of Outback navigation.

"Ease off to the right a bit," he said after takeoff. "There, that ought to do it. In

about 20 minutes we should see a sort of odd-looking hill . . ."

Somehow we found his homestead and landed. "After you leave," he said, leaning into the cockpit, "fly the length of my strip, then turn left to go over the roof of the shearing shed over there. Hold that course and pretty soon you'll see the Olgas."

"How soon?" the missionary asked, casting an eye on the fuel gauge.

Our passenger shrugged. "Depends on the wind. Today's easy. You'll be right."

Everyone flies everywhere in the Outback, sometimes with the help of a navaid or simply by calling home on the radio. Mostly, those who fly here find their way by subtle marks on the earth as familiar to them as a lightning-struck oak is to a Tennessee farmer. Land owners fly to dinner parties. Horses are flown to picnic races. Flying doctors earn fame snatching patients from meager landing sites. Circuit judges fly in; criminals fly out.

"Bluey," an Outback figure of the 1930s notorious for shooting first and arguing later, once gunned a man down in the northwestern gold country. The judge dared give him only a month for having an unlicensed pistol. Bluey was packed off to jail at the Alice in a twin-engine de Havilland, and en route one engine died. They landed on a flat piece of desert. Bluey walked off, trudged the desert for a week, got help for the others, became a national hero, did his time, and married an heiress.

The old de Havilland airliners carried all kinds of cargo in the Outback. One pilot had trouble loading a coffin into the cabin, so before the passengers were boarded the deceased's relatives removed the departed from the casket and propped him up in a seat, an open newspaper in his hands.

Even today, Outback flights provide a steady stream of stories. One attendant on

an Australian Airlines flight out of Darwin stored a passenger's crate of mud crabs—a local delicacy—in the galley of a 737. After they had landed in Adelaide, the attendant got on the speaker and announced, "It is important to remain seated until the plane comes to a full stop. And will the gentleman who gave me the crabs in Darwin please see me?"

I glanced over at the missionary, a big, bearded, kindhearted Aussie in shorts, sprawled in the Cessna's left seat, going over notes of what he was going to say to the tribal settlers of the Pitjantjatjara—if we ever found it. I wished he'd take the controls. It was his damn airplane—let him watch the fuel needle sag, the compass swing lazily, the emptiness unroll beneath us. I wished he'd at least *worry*.

But you don't worry in the Outback, particularly if you enjoy a pipeline to God. Suddenly a finger tapped me and pointed to a small earth-red scar on the barren landscape. "Well done," he said. "I've missed that strip by much more than this."

Had he, I wondered, or was this the usual Outback put-on? They still tell of one pilot who regularly flew tourists from the Alice to Ayers Rock. He'd arrive early at the airstrip, clad in greasy shorts, stained undershirt, and battered broad-brimmed hat. Sitting on the aircraft's cabin stairs, he'd stare blearily at the dust, the very picture of a raging hangover.

When the passengers arrived, they'd have to step distastefully around him. "Where's the pilot?" he'd mutter. And when they were all seated he'd poke his head into the cabin and ask, "Has anyone seen the pilot?"

There'd be only an embarrassed silence. "Well," he'd sigh, "I guess I'll have to fly the bloody plane myself."

—Edwards Park

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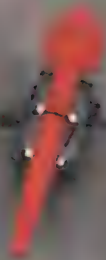
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506-200



When this naval aviator gets shot down,
he chalks it up as a success.

Ensign Nolo, USN

On the beach some 40 miles north of Los Angeles, a weather-beaten launch pad suddenly erupts with a loud blast. A stream of smoke trails behind an orange blur streaking out to sea. This unmanned drone will soon have company—somewhere over the horizon a Navy F-14 Tomcat is looking for a target.

In a cinderblock building about a mile from the pad, a dozen Navy and civilian workers at the Pacific Missile Test Center at Point Mugu hover intently over rows of consoles. The action focuses on the drone's pilot, who sits at what looks like a computer desk with cockpit instruments. On a TV screen above his console he watches a graphics display to see where the Ryan BQM-34S Firebee is on the target range. Two symbols are closing in on each other—one is the Firebee and the other the F-14.

The \$30 million Tomcat is armed with Sparrow missiles, but instead of warheads the Sparrows carry telemetry packages. This is a test in which the drone is carrying electronics intended to counter the F-14's radar.

"Two miles," a voice in the control center calls out. "C'mon baby," mutters test director Lyle Brown.

"We've got a skip," the first voice reports. The F-14 has not been able to

track the Firebee. Whatever electronic spooking the mini-jet is broadcasting seems to work. Both aircraft maneuver for another head-on approach. "Don't fly over any of those contacts," Brown warns the drone's controller, pointing at a number of small triangles on the screen. Each indicates a surface ship moving through the range.

Closing in on its target a second time, the F-14's radar is again foiled by the Firebee's electronics. "We're low fuel on the target," advises a controller. Brown nods. With only 600 pounds of fuel, Firebees are limited to about 20 minutes of flying at 500 feet or lower.

"How much fuel ya got, Bob?" Brown asks. Bob shakes his head. Brown decides it's time to wind up the exercise. "We're comin' right to recovery," he announces. The Firebee is guided back toward the designated recovery area. As the drone runs out of fuel, its nose pitches up, its tail cone drops off, and a drag chute pops out, pulling the main chute with it. The drone floats gently downward to the sea. There it drifts with the currents, broadcasting a location signal to guide a CH-46 Sea Knight recovery helicopter.

When the helicopter arrives, a crewman lassos the drone with a hook. Dangling beneath the CH-46, the Firebee is returned to Point Mugu, where the Day-Glo orange drone is delicately deposited on a large yellow square pad. After the helicopter departs, technicians use a crane to lift the drone from the retrieval pad and manhandle it onto

a dolly. They wheel the drone into a maintenance hangar, where it will be disassembled for a freshwater bath to remove the ocean salt.

This presentation is over; the drone will now be readied for its next.

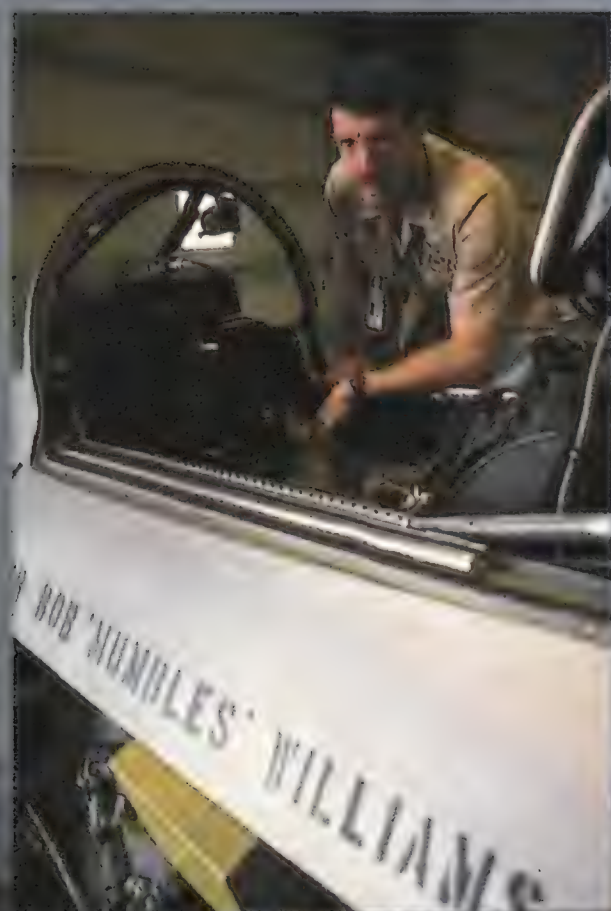
At Point Mugu (pronounced like the name of the cartoon character Mr. Magoo), "presentations" refer to the use of airborne target drones. The Pacific Missile Test Center is the Navy's primary facility for testing and evaluating air-launched weapons. Missiles being what they are, much of the work at Point Mugu requires a target. Which is where the Targets Directorate—the outfit that maintains, operates, and presents the drones—comes in.

"Our job is to present targets to Navy pilots engaged in either operational training or in the development of new

A red plug installed in the connector of this avionics unit indicates that the craft is flown by "no live operator"—Ensign Nolo.



Navy targets come in all shapes and sizes, from the relatively simple towed platforms to F-4 Phantoms and F-86 Sabres modified for remote control.



missile systems," says Bob Williams, commander and aircraft targets officer. In the overall scheme of things at Point Mugu, the Targets Directorate is relatively small compared with the directorates that consume the drones—especially the Weapons Evaluation and Systems Directorates (or, as Williams would say, "the guys that are shooting at us").

Some presentations are made by the small, bright orange aircraft known as sub-scales. Others are flown by full-scales: actual jet fighters piloted, like the sub-scales, by remote control. Both types of drones can be recovered if necessary. Full-scales are guided to an ordinary landing on a runway, but the sub-

scales have to be dropped into the ocean and retrieved later.

There's no shortage of people who want to shoot at the drones. Tests at Point Mugu have recently included target shooting by an advanced medium-range air-to-air missile system developed jointly for the Navy and Air Force. Pilots of the F-14D, the latest version of the Grumman Tomcat, which has more powerful engines and improved avionics, have also been keeping the Targets Directorate busy. Fleet training uses a big share of drones—each new warship that comes out of the yard shoots at targets during sea trials conducted prior to its entry into the fleet.

Other regular drone killers are rookie fighter pilots, though the rookie flights are not unrestrained mix-'em-ups. "We can't just say 'Here it is, shoot it down,'" says Williams. "They don't just jump the drone and pick it off. That would be too easy and it wouldn't be good training. We try to give them a challenging situation."

"We don't *intentionally* make them look bad," elaborates Michael O. Jones, a former Navy lieutenant commander who now flies drones as a civilian contractor to the Navy. "It's *very* structural choreography." The fighters take their shots only at pre-determined

A JATO (jet-assisted takeoff) rocket bottle hurls a Ryan BQM-34S Firebee into the sky from Point Mugu's ground launch facility (left).

Retired Navy lieutenant commander "Mo" Jones returned to the Pacific Missile Test Center as a civilian to fly drones (top inset).

Former A-7 pilot Bob Williams is in charge of presentations for the Targets Directorate (below inset).

Mugu's Workhorse

With a length of 22.9 feet, a wingspan of 12.9 feet, and a weight of 1,500 pounds, the Ryan BQM-34S Firebee is the primary aerial target at the Missile Test Center at Point Mugu. Capable of both air and ground launch, the state-of-the-art drone can achieve a speed of up to Mach .97 and an altitude in excess of

60,000 feet. Powered by a J-69 engine with 1,920 pounds of thrust, the Firebee has the ability to stay aloft at high altitude for almost two hours.





The Targets Directorate has a Lockheed DC-130 that can launch drones from the air. The airplane can carry four drones beneath its wings. At right, a Firebee drops away to begin a presentation.

DAVE GOSSETT/TELEDYNE RYAN AERONAUTICAL (3)



points in an exercise, which might call for the aircraft to attack while the target is, for example, pulling a 4-G turn to the left.

The most common mistake new pilots make is something Jones calls "buck fever"—shooting before they've gotten close enough. "Switchology" is another malady that is common to most rookies. "Sometimes they're so busy flipping switches while trying to get set up for the shot that they miss their chance," Jones says.

But during most presentations, pilots miss on purpose. Dwindling supplies and new budget realities often require "telemetry shots"—missions in which an attacking missile's explosive warhead is replaced by an electronics package and its telemetry recorded by a trio of antennas mounted on a full-scale's tail and wingtips. Near-misses by shells fired from guns can be detected and recorded the same way. If the projectiles miss by a pre-arranged distance, the shot is judged a "hit" and the target survives to fly another day.

In Point Mugu's aerial chess game, the pawns are the sub-scales—small

jets roughly a half to a third the size of a full-size fighter. They range from the small and relatively slow Northrop BQM-74C "Chukar" (top speed: 688 mph) up to the Mach 4-capable Beech AQM-37C. They can be launched from land with JATO (jet-assisted takeoff) bottles or dropped from an airplane. Once under the command of controllers on the ground, sub-scales can fly whatever profile is required—straight and level, weaving back and forth, or a hard turn.

While expendable, the drones aren't cheap. Point Mugu's workhorse, the one-ton-plus Firebee, costs \$450,000. "Sub-scales are more than just a barn for them to shoot at, more than just hulks," says missile target engineering supervisor Marshall Lacroce. They can deploy strips of aluminum foil called chaff that confound a radar homing system. They can carry electronics pods to deceive or jam missiles. Some drones can even launch flares for heat-seeking missiles to home in on.

Despite their versatility, sub-scales sometimes aren't enough. Only full-scale drones—obsolete jet fighters con-

verted to radio control—can simulate certain targets. If sub-scales are Point Mugu's pawns, then full-scales are its bishops or rooks. Not only are they larger, full-scales are also more easily adapted for carrying additional systems, such as the electronics pods used for Electronic Warfare Directorate tests. As far as fighter pilots are concerned, full-scales are also more like the real things. "We're not going to be shooting down a BQM-34 with a Sidewinder when we're in battle," says Williams.

To convert a fighter into a radio-controlled drone, technicians begin by adding a system of electromechanical servo controls. Except for its sophisticated telemetry equipment and a small black-and-white TV camera mounted in front of the cockpit, it's not unlike a radio-controlled model airplane. Once equipped, the airplane is said to be under the command of "Ensign Nolo," short for "No Live Operator."

Should pilots lose control of a Nolo aircraft due to loss of radio link or mechanical failure, the onboard electronics take over and fly the aircraft straight and level on a heading away from popu-





Its presentation over, a Firebee deploys a parachute and splashes down in a designated recovery area (above).

There, a recovery crew lassos the drone to fly it back to Point Mugu. Drones often broadcast a location signal to help helicopters locate them in the ocean.

lated areas. Ensign Nolo will automatically maintain that course until the drone runs out of fuel and falls into the sea. Average fuel loads keep the airplane's range under 600 miles.

In the last 10 years, the Navy has been using the F-86 Sabre, a vintage fighter from the 1950s, as a full-scale drone. Since being introduced as targets, nearly 200 radio-controlled F-86Fs (redesignated as QF-86Fs) have been presented to Navy aviators and the fleet. The latest batch, from Japan's Air Self-Defense Force, are immaculately maintained and have only 1,300 to

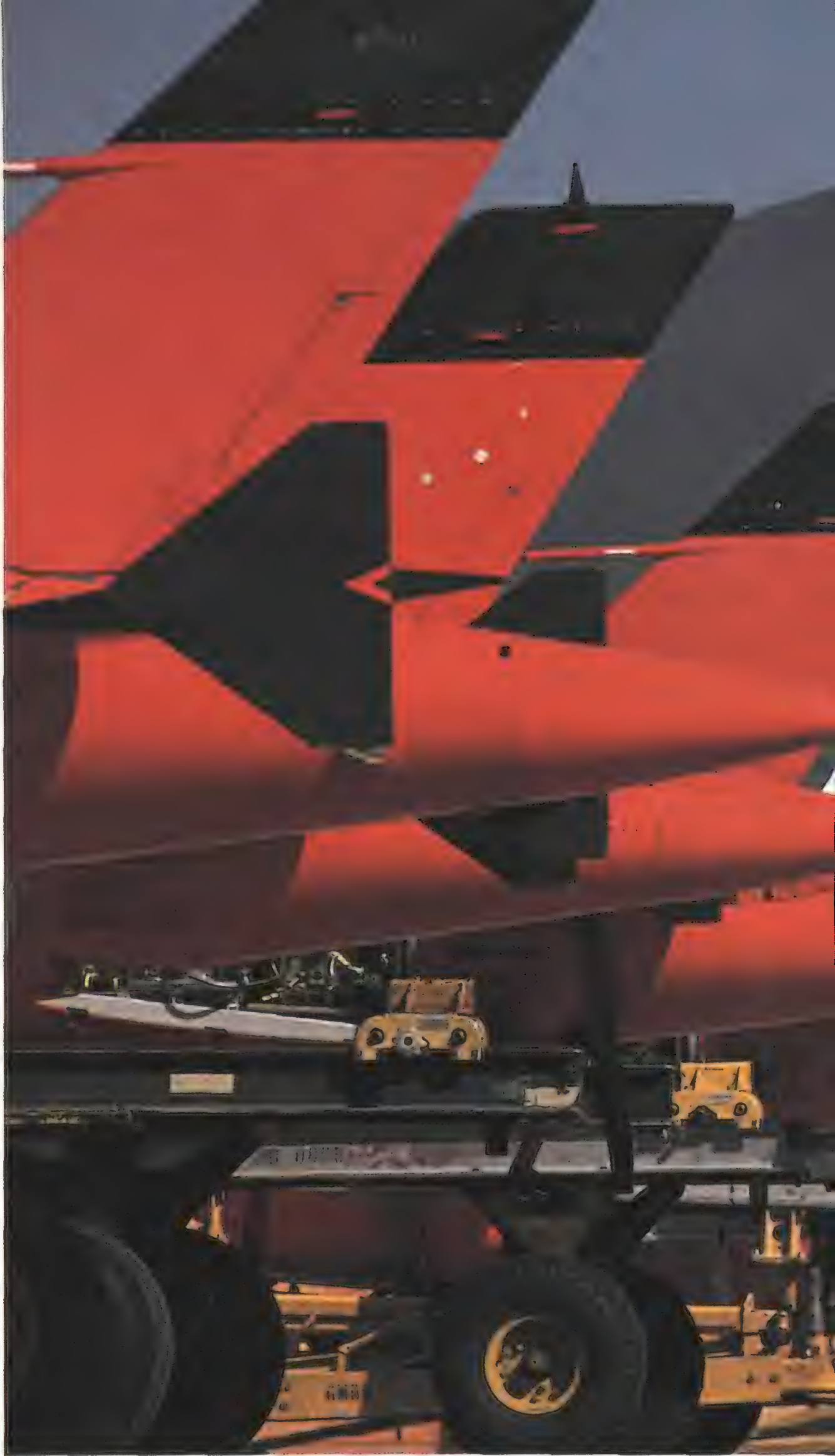




In preparation for the next flight, mechanics refurbish a Firebee's J-69 engine (below).

"You can't think of how much the machine you're flying costs," says missile target engineering supervisor Marshall Lacroce (bottom).

A technician adjusts one of the Firebees on the flight line. Behind him is Laguna Peak, Point Mugu's primary radar site.



1,500 hours of flight time each. Out of the 279 flights Ensign Nolo has flown with the F-86, he has been shot down 73 times.

Although telemetry presentations have extended the lifetimes of the F-86 targets, the supply will eventually be

exhausted. "We keep presenting them until they get shot down," says Williams. As the supply of airworthy F-86s dwindles, obsolete Navy F-4N Phantom IIs are getting their shot at fiery death over the ocean. The QF-4 was introduced in 1986, and out of 26 Nolo



flights, it has been shot down six times. "It's a shame in some ways," admits Jones. "I wish we could refurb some of them. But the way it is, we either fireball 'em or make 'em into beer cans."

Full-scale presentations take off from a 10,000-foot runway on a rocky island

known as "San Nick." Roughly 60 miles from Point Mugu and below the Channel Islands, San Nicolas Island is also a spectacular wildlife refuge and the site of about \$30 million worth of sophisticated missile tracking and drone radio control equipment. A wide area of ocean sur-

rounding the test range is also monitored by Navy radars and surveillance aircraft.

Pilots fly full-scales with a universal console controller, a cockpit mockup similar to a generic simulator. It features a stick grip, a couple of throttles,



Point Mugu's recovery crews use the CH-46 Sea Knight helicopter. The Naval air station has four for recovery operations.

and the standard instrumentation.

"Once you get 'em airborne, they're like a simulator but with no seat-of-the-pants sensation," says Jones. The biggest difference is that the only visual reference is provided by the full-scale's television camera, which has a 30-degree field of view. That doesn't allow much of a horizon reference, though the television screen mounted above the controller's console is useful when the pilot really needs to see where he is on the runway during takeoff and landing.

"What it really amounts to is just like flying on instruments or flying in the clouds," says Williams. Before a pilot flies a drone by remote control, he must first acquire hands-on proficiency with the aircraft type. The next step is to remotely pilot full-scales from the ground control station while a safety pilot rides shotgun in the cockpit—a stand-in for Ensign Nolo.

"It's a little weird riding in a cockpit by yourself while someone else who

isn't even there flies the airplane," says Jones. Landings are the hardest. "It's tough to just sit there," Jones says. "If your remoter is new to it, you might talk him down a little. And you stay ready to take over if he starts to lose it, because after all, *you're* in the airplane and he isn't."

Once qualified, remote pilots must keep their flying skills sharp. Maintaining the descent angle on approach to the runway is the most difficult task. "Of course, that's not so important when it comes to the Phantom," says Williams, "because that airplane was designed for carrier landings. All you do is establish a three-and-a-half-degree glide slope and slam it down. Do that with an F-86 and you'll fold it up."

Not long after a fallow flying period, Jones was on approach in a QF-86F. He flared too high above the runway, tried

again, and dropped the full-scale on the ground so hard he snapped off the nosewheel. The airplane skidded to a halt, grinding its bare metal chin into the concrete.

In the air, full-scales often surprise both pilots and pursuers with their toughness. "We've had F-86s come back without their horizontal stabilizers on one side and without a good-sized chunk of their tail," says Williams. "A missile without a warhead still packs quite a wallop."

On a Navy test range near Puerto Rico, a flight of four Navy F/A-18s was recently presented with the uncommon opportunity to engage in an impromptu dogfight with a damaged F-86 full-scale. "We could probably have gotten it back to base," says Williams, "but [Naval Air Station] Roosevelt Roads is near a populated area, and we want to keep aircraft in that sort of condition away from populated areas." The airplane was offered as a sacrificial lamb for the F/A-18s—a real treat for the pilots, who seldom get a chance to fire live ordnance at a real target.

So it was four of the Navy's top fighters against a single F-86 flown by Ensign Nolo. The fighters didn't have any missiles left so they went after the drone with guns. The F-86 kept making hard turns, eluding the fighters' guns. Finally, a junior officer nailed it.

Tests and exercises are so rigid that remote pilots seldom get a chance to put Ensign Nolo through all his paces. But sometimes, when there are no fighters available to shoot up a damaged drone, "we get to see just how much an old fighter airframe can take," says Williams. "So we wring it out. Do all the things the handbook says you can't do, or shouldn't do. Outside loops. Ten-G turns. Ditching. Slamming it into the ocean at 400 knots."

Williams considers such an opportunity "a bit of a treat." Undoubtedly Ensign Nolo would have a somewhat different attitude. It's his fate, however, to be always in the hands of others. Yet even when Ensign Nolo crashes it means that another mission has succeeded. And each time he survives a mission, Ensign Nolo gets both decorated and promoted. But, says Williams with a wink, "he's never made it past lieutenant commander." —

Score one for Ensign Nolo. In a reverse of the tradition of painting a silhouette of a kill, this survivor gets stenciled when a missile misses.



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NATO'S **NOISE** PROBLEM

by William Triplett

Architect Roswitha Schlueter is working at her drafting table in Rissdorf, a village between Bonn and Cologne in West Germany. Suddenly a shriek rips the air, so loud it deafens her to all other sound, shattering the pastoral quietude and with it Schlueter's nerves. She erupts in uncontrollable weeping.

"I'm only 34 years old," she says later. "This is not normal!"

But it is. Upwards of 100 times a day, five days a week, every week of the year, such horrendous noise can explode without warning from NATO fighter jets—American F-16s and A-10s, European Tornados, and Canadian CF-18s—playing war games at low altitudes. Every year NATO aircrews chalk up an average of 68,000 hours of such low-level flying in West Germany. In most parts of the country pilots do their ear-splitting rehearsals at 500 feet, but in seven designated zones, like Rissdorf, NATO's floor drops to 250 feet.

"They have come 30 times already just this morning," Schlueter says. "I have had to interrupt three phone conversations because of the noise. It is terrible!"

NATO's jets have been screaming overhead since the 1960s, but with the rise of the European peace movement over the last decade, more and more Germans have begun to protest. At first the opposition was limited to the radical Green Party and other environmentalists. Then in 1988 a string of crashes—including three in one day—added fear for safety to the suffering caused by the noise, and the built-up resentment roared into a national issue.

"You will hardly find a politician from *any* party speaking up for low-level flying now," says Kurt W. Fredemann, a spokesman for the West German Ministry of Defense. "It is a

very sensitive issue." And yet in the face of a recent incident, the April 17 collision of two F/A-18s over a city of 300,000, Chancellor Helmut Kohl's coalition government issued a statement reiterating support for the massive concentration of NATO forces in West Germany. Kohl is not deaf to his countrymen's pleas, but as a member of NATO he has few options.

Since the late 1950s members of the North Atlantic Treaty Organization have realized that the U.S. nuclear umbrella alone could not protect Western Europe against Soviet aggression. Once it became obvious that a U.S. nuclear strike against the Soviet Union would be answered in kind, the United States quickly developed the doctrine of flexible response. The theory was that the U.S. strategic nuclear force no longer offered a credible deterrent to small aggressive actions, such as a border dispute or a painful but not paralyzing blockade. A conventional force, on the other hand, might deter the action. Failing that, it might thwart the aggressor's military objective and prevent escalation to a nuclear level. At the very least, it provided more choices than nuke or surrender.

The United States spent 20 years urging its allies to adopt the flexible response strategy, the policy that has guided the buildup of conventional arms in the United States and Europe. But by all estimates, that buildup has not kept pace with the Warsaw Pact's.

"In the early '70s the East began improving its air defense system," says Don Snider, associate director of defense policy studies at the Center for Strategic and International Studies in Washington, D.C. "By the end of the decade it was extremely sophisticated. [NATO's] low-level flying definitely intensified commensurate with the increasing sophistication of the East's system."

"It makes what they had in Vietnam look like a cakewalk," says Colonel Jeff Cliver, a former F-15 wing commander who is now assistant director of operations for U.S. Air Forces Europe (USAFE). "If we were tasked to do something against the East, the only way

High over Garolstein Castle in West Germany, F-15 Eagles look serene, but university studies of the effects of their noise have led a European assembly to brand them "intolerable" at lower altitudes.

GEORGE HALL

It's anything but quiet on the Eastern Front.



FRANK MORMILLO

Public outcry may persuade NATO to substitute simulation for training in noisy terrain huggers like the European-built Tornado strike aircraft.

we could meet that system would be at low level, where it's harder to see us or hit us. Low-level is our escape-and-evasion tactic."

The pilots whose aircraft are bedeviling the German citizenry are training to escape surface-to-air missiles and to evade anti-aircraft weapons that acquire their targets by radar. Before a practice mission, they receive "tasking orders" for one of two kinds of missions: close support of ground forces or a deep strike behind enemy lines. The weapons the pilots would face are mobile and plentiful, requiring terrain-masking maneuvers over the battle line or behind it.

An F-16 pilot simulating a close-support mission receives orders to fly a certain distance at high altitude to an "initial point," imagined to be near a battle, where he drops to low altitude to evade radar. He is then guided by an airborne forward air controller to a "target," which, like tanks or troops, would be moving. "In a typical scenario, he would approach the target at near-treetop level, then pop up near the target to gain sight and attack it," says Lieutenant Colonel Rodney Thompson, assistant chief of fighter operations at USAFE headquarters in Ramstein.

The imaginary scenario in which the pilot trains is, however, very different from what is actually happening on the ground. "There have been funerals in my village when the priest must stop speaking because no one can hear him because of the jets," says Albrecht Müller, a Social Democrat member of parliament. "When this happens even the most conservative people begin to object."

When the complaints became nearly as noisy as the jets, NATO agreed to end weekend and lunch hour sorties. The concession permitted weddings, church services, and other weekend celebrations to proceed in peace, but many people continue to cringe during the week while the jets pretend to attack. It is an especially cruel menace to those who have difficulty distinguishing pretend from real. Peter Altherr, a child psychiatrist who runs a clinic in one of the numerous 500-foot areas, recently completed a study of the long-term effects of the noise on

mentally ill children. "We found children suffering from death anxiety and panic attacks as a result," says Altherr. "They sometimes believed themselves to be dead. During the night children would wake up crying and scared. During the day when the jets roar over, children would either shake or stand perfectly still for about a half-hour. What we determined in the end was that if you wanted to induce anxiety neuroses or childhood depression, this noise would be an excellent method."

NATO has never pretended the sound of freedom ringing in your ears was easy to live with. "This is something Americans don't often understand," says U.S. Air Force Major Iris Galan, a NATO spokesperson in Holland. "The U.S. is always crying for more burden-sharing among NATO members, but the U.S. tends to think the burden is only money. This noise is very much part of the burden. Germans have to put up with it. Americans don't."

Yet NATO is not ready to stop saddling the Germans with this particular burden. To those responsible for protecting Europe, the overwhelming superiority of Warsaw Pact conventional forces constitutes a real threat. For example, if hostilities between East and West led to war, the U.S.S.R. and its Eastern allies could send up to 13,900 combat aircraft against NATO's 5,900.

But as long as Soviet president Mikhail Gorbachev offers to limit intermediate-range nuclear force (INF) deployments, conventional forces, and military spending, civilians see the threat as a figment of the military imagination.

"There is no more enemy now," declares Werner May, national coordinator for Groups Against Low-Level Flying in Germany. The 150 opposition groups included in his organization are growing, he says, "because more and more people see that events in the East have given us a very strong argument to stop this."

The German Air Force operates a telephone line strictly for noise complaints. In 1988 about 6,200 complaints were lodged; in 1989 the number rose to 8,700, an increase of almost 40 percent. In November 1989—when the Berlin Wall came down—the number of complaints was double that logged for November 1988.

"Gorbachev really does make the noise seem louder," says Alfred Mechttersheimer, a former German Air Force officer who is now a Green Party representative in parliament and a staunch opponent of the flying because he too believes the threat is gone.

"When evaluating threat," Major Galan counters, "you need to remember it consists of two parts: intent and capability. Only the intent has changed recently. The equipment and manpower is still there. Can NATO afford to overlook that capability even when intent is minimal? No."

The reductions in conventional forces in Europe currently being negotiated in Vienna may eventually shrink capability to intent's current size, but as Fredemann says, "We are only *talking* reductions now. To date there have been no reductions." According to NATO officials, the U.S.S.R. still has 250 MiG-29s and 385,000 troops in East Germany alone. Says USAFE spokesman Captain Ed Worley, "The Bear still has claws."

The civilian refusal to accept the military definition of threat has led many on the military side to believe that the opposition groups simply don't understand security issues. And the military inability to adjust security strategies to the rapid political changes in Eastern Europe has convinced the opposition that the military establishment cannot live in the real world.

"The military always speaks as if it's in a vacuum," says George Pumphrey, a member of the Green Party who is an assistant to Germany's parliamentarian. Pumphrey speaks so intensely on the subject that his listeners can hear exclamation points. "The Bear still has claws because the *Eagle* still has claws!"

"Do you think the U.S.S.R. could attack us even if they wanted to?" asks Müller. "They have too many internal problems to attack anybody. If you study the situation at all you'll

see the possibility of attack is just plain silly. The military's thinking is so backward it astonishes me."

Readiness is only part of the motive that keeps NATO jets in the air. Low-level missions also carry a powerful symbolism. "Deterrence is a function of perception," says Don Snider. "The enemy has to believe we are prepared and ready to do something. Readiness only has its value in that it influences the perception of the adversary—it makes deterrence real." Diego Ruiz Palmer, director of the NATO Studies Center at BDM International, a consulting firm in McLean, Virginia, points out that the symbolic mission of low-level training may have helped produce the very changes that its opponents cite as reasons for stopping it. By examining published Soviet studies, his firm learned that in the early 1980s Soviet planners had concluded that knocking out NATO air capability was essential to a successful campaign in Europe.

The controversy has never been exactly cordial, but the loosening of the Soviet hold on Eastern Europe and the impending unification of Germany have further polarized the civilian and military groups.

"The problem of the debate is it's on two separate levels," says Lieutenant Colonel Konrad Freitag of the German Air Force Tactical Command in Cologne. "The military argues on the rational level, and the opposition argues purely on the emotional level."

"The German people have been irrational in *not* protesting," says Müller. "They have been playing the role of lambs ever since the end of the war, just accepting things that are told to

Computer-generated Tornados cruise over a visual database—a southeast German landscape re-created from U.S. Defense Mapping Agency digital data.

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them. The protesting is much more rational than all the silent suffering that went on before. Germans are no longer accepting the nonsense that low-level flying is necessary. They've been cheated on it and don't want to be cheated anymore."

"Every time you ask the military why they keep doing low-level flying, they have a new answer," says May. "But they've lied so often in the past about why they do it, we don't believe them anymore."

Some who oppose low-level training, like Pumphrey, would gladly junk the whole deterrence strategy. "We believe it's time for new security thinking!" he exclaims. "We do not believe security comes from two armies ready to destroy each other!"

The great political changes in Eastern Europe have brought the controversy to what is probably its final impasse. Last fall NATO agreed to a 45 percent cut in low-level flying time, and Allied air wings are occasionally redeployed to other countries for training. But to hardliners like Pumphrey redeployment is hardly an answer "because it is a *racist* position. It assumes the local populations in those places like Goose Bay [Canada], where the jets fly even *lower*, don't exist!" And reducing flying doesn't appease the increasing number of people who are calling for its complete elimination.

"We can't do that," says Air Vice Marshal Allan Blackley, an amiable Scot who's deputy chief of operations at Allied Air Forces Central Europe. "All our weapons and avionics are

designed for low-level tactics. If we were to cut low-level we would have no technical or operational alternative for the foreseeable future."

Ultimate resolution will come only when Germany's leaders, NATO's political heads, and diplomats and politicians all over Europe and in the United States sort out the numerous interrelated issues swirling out of Germany's current events. Maintaining the security of Europe will depend on the details of German unification, the outcome of the still-evolving Vienna talks, the German national elections in December, and the effect of a growing sentiment among Germans that their country is still "occupied" by foreign military powers. This feeling has led to serious discussion of German withdrawal from NATO.

Defense minister Gerhard Stoltenberg has already made perhaps the one definite statement that can be made for the moment—until the new "security situation" in Germany is figured out, there will be no further cuts or changes in the flying.

"That makes me so frustrated!" cries a weary and jangled Roswitha Schlueter into the phone. "We cannot enjoy our garden because of the noise. We cannot open our windows or doors on pretty days because that is when they fly the most. We actually look forward to bad weather because that's when they don't fly. We—" Her voice suddenly disappears under a shrieking roar. "*Do you see what I mean?*" she cries over the jet engines. "*Can you call me back later?*" —

More than 200 F-16 Fighting Falcons fly low-level training missions over Europe. Over 20 have crashed in West Germany since 1981.

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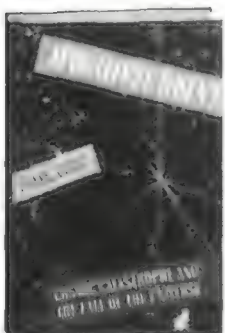
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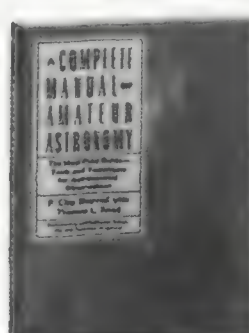
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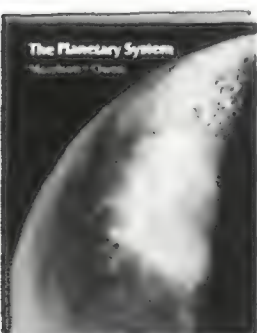
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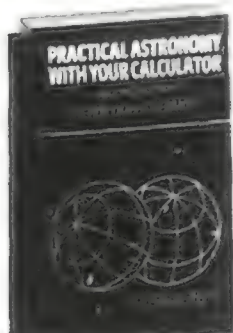
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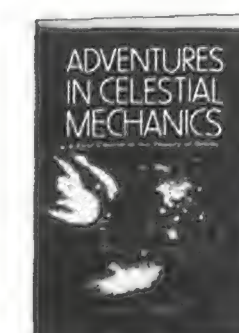
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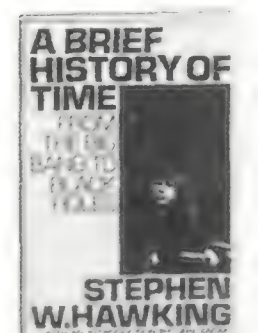
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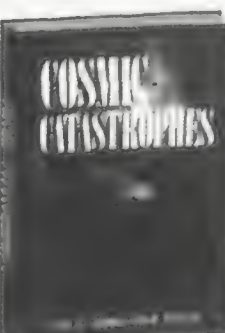
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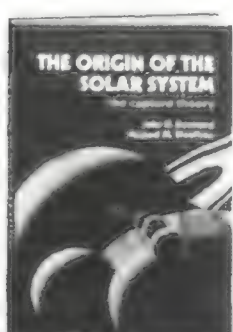
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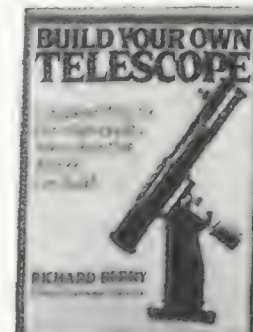
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Two Faces of Catastrophe

The different ways NASA dealt with the Apollo fire and the *Challenger* explosion illuminate how the space program has been transformed by forces beyond the agency's control.

by Wayne Biddle

On the afternoon of January 27, 1967, a group of senior government officials and corporate leaders gathered at the White House for cocktails with Lyndon and Lady Bird Johnson. The occasion was the signing of the Treaty on the Peaceful Uses of Outer Space, one of the Cold War's few diplomatic successes. But the feelings of elation would disappear later that eve-

Illustrations by Paul Salmon

ning when horrible news traveled northward from Cape Kennedy. Three Apollo astronauts had died in a test capsule fire on Pad 34.

Two decades later, on January 28, 1986, a new generation of officials and executives turned on their televisions to watch the blast-off of the space shuttle *Challenger*. The shuttle launchings had become almost routine, but there was

heightened public interest in mission 51-L. Its seven-person crew was the most universally appealing ever assembled: it included an Asian-American, a black, as well as two women, one of whom was a schoolteacher. *Challenger* lifted off at 11:38 a.m. and rose into the heavens for 73 seconds, then blew itself to smithereens, leaving a hideous forked pillar of smoke in the sky.

In the aftermath of the explosion and its endless television replays, NASA and a shell-shocked nation underwent much soul-searching. But neither NASA nor the nation reacted the way it had 19 years earlier after the Apollo fire. In 1967 NASA had been the prosecutor in its own investigation; in 1986 it became the defendant in the most wrenching public trial of its history.

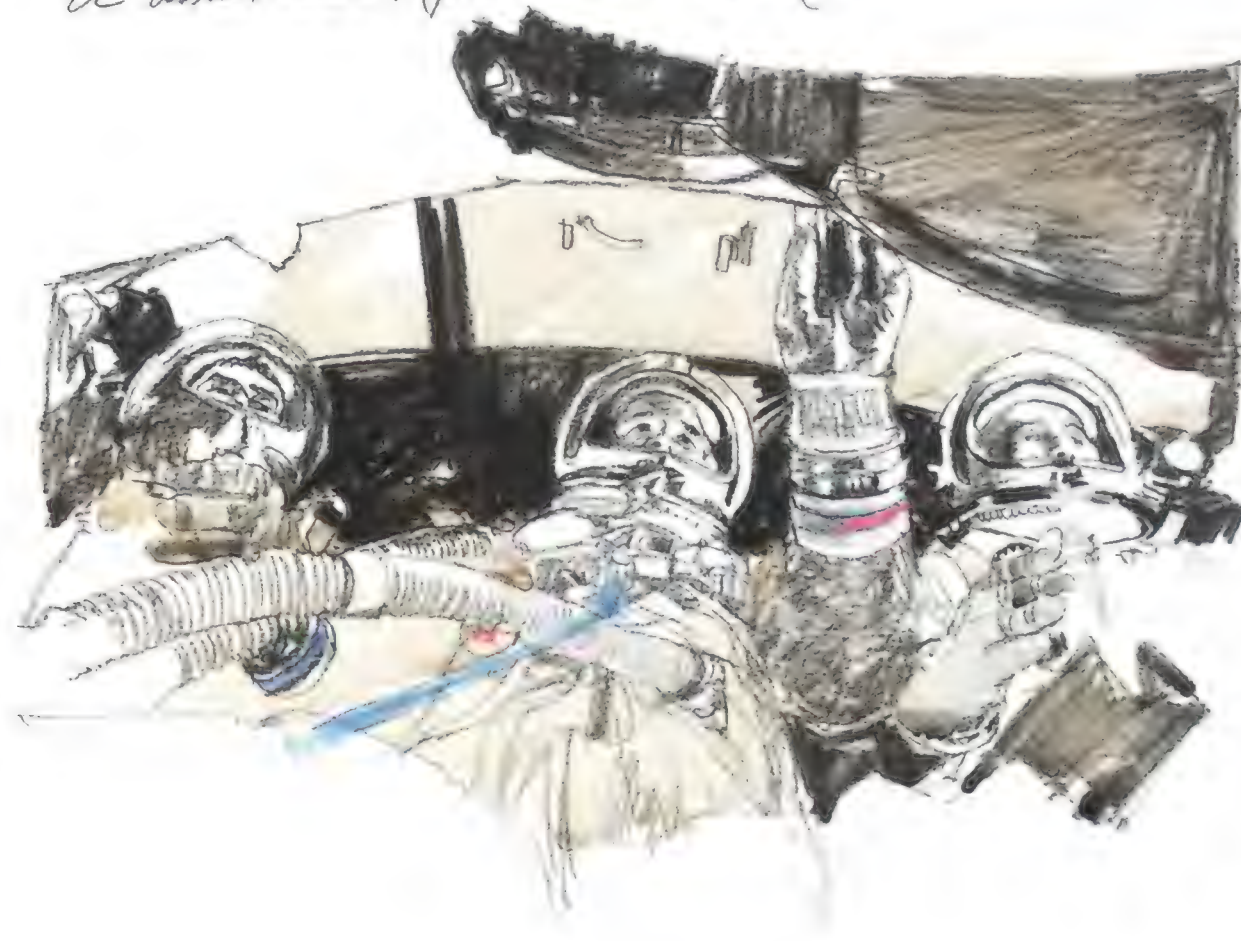
On the afternoon of the *Challenger* disaster, acting NASA administrator William Graham paid a visit to the White House, where President Reagan assured him that the nation's commitment to space would continue. After a photo session and a Reagan quote for the news media, Graham was rushed to Andrews Air Force Base to accompany the vice president to the Cape that same afternoon. So precipitous was the exit that Graham's wife had to rush a suitcase of clothes to her husband.

Meanwhile, at the Cape, NASA associate administrator Jesse Moore issued the agency's first public statement five hours after the accident. "I have taken an immediate action to form an interim investigating board to implement early activities in this tragedy," he announced, following NASA procedures in place since Apollo days. "A formal board will be established by the acting administrator very, very shortly."

But this was not to be. Even before Graham's visit to the Oval Office, the White House chief of staff, Don Regan, had urged the president to form a blue ribbon investigative panel. The initiative was already out of NASA's grasp.

"In my judgment, to have allowed NASA to investigate what went wrong and then give a sanitized version to the public would never satisfy," Regan says today. "The atmosphere in Washington had changed from the 1960s. We had an adversarial press—much more so than Jack Kennedy or Lyndon Johnson had.

A disastrous Apollo 1 rehearsal



We also had a much more adversarial Congress that had been through Watergate and several other scandals. Frankly, as a business person—not as a scientist or a government official—I recognized that somebody had screwed up. Who? It had to be the organization [NASA] itself. To allow the organization to investigate itself was not the proper conduct.”

When word got out that a non-NASA commission was under consideration, opposition mounted quickly. “Jim Fletcher hit the roof,” Regan says, referring to the former NASA administrator who had led the agency through much of the space shuttle’s troubled development in the 1970s. “Up on the Hill it was mainly [Senator] Jake Garn and [Congressman] Bill Nelson,” NASA’s two most gung-ho and vocal allies in Congress.

People who opposed the formation of a presidential commission “were afraid that Graham was a White House toady, that he was going along with us to protect his job,” Regan recalls. He adds that one conduit for these objections was John Poindexter and the National Security Council, who made the plea that “if there was an independent group, maybe too much national security—some of the satellites that NASA had been putting up—might get compromised.” But this was “a bluff,” Regan believes. “That’s the usual Washington thing, the ‘Washington Monument’ [position].”

The final decision to go with a presidential group was made on the president’s airplane coming back from the memorial service for the *Challenger* crew on January 31 in Houston. “We met in the president’s cabin, John Poindexter and I,” Regan remembers. “I came on quite strongly that ‘We can’t afford a charge of coverup here.’” After the meeting, Al Kingon, secretary to the cabinet, walked back from the president’s private section of Air Force One to inform Graham of the decision.

Nineteen years earlier, events had gone differently. On the day after the Apollo 1 capsule fire, James Webb, the NASA administrator who molded the Apollo program from its inception, went to the White House. “They’re calling for investigations,”

Webb explained to the president. “The science advisory group in the White House is being pointed to as the proper body. A lot of people think it’s a real issue for the future, and that you ought to have a presidential commission to be clear of all influences. You can have any investigation you want, with my full cooperation.”

The scene was pure LBJ. “He was in his pajamas in his bedroom after lunch,” Webb remembers. “I said, ‘If you want me to do it, I’ll tell you what I think the job is—to find out what caused this fire and the loss of life, fix it, and fly again so we can complete the Apollo mission. If you want me to do that, I’ll do it. NASA is the best organization [to do the investigation].’”

Johnson did not take long to mull over the options. “He looked at me and thought a minute, then said ‘okay’ and stuck out his hand to shake,” recalls Webb. “It was the only presidential deal I ever made where I shook hands in the president’s bedroom. You don’t usually need to do that. This points to the fact that it was a big thing.”

Indeed, it was a very big thing, one of the crucial political decisions of the Apollo years. It was also typical of Johnson’s brand of personalized deal-making, and Webb was supremely capable of taking maximum advantage of such intimate power-brokering. What the president hadn’t known was that NASA already had the membership of an investigative board in place.

Webb’s reputation even to this day is that of a combative bureaucrat who guarded his turf with canine ferocity, albeit in the name of a successful lunar landing. Early on he proved his mettle in battles about manned spaceflight with the President’s Science Advisory Committee. Webb was not about to stand by while outsiders vivisected Apollo.

Thus, when Webb gripped the sleepy president’s outstretched hand on the afternoon after the fire, NASA was firmly in the driver’s seat. Webb promised to deliver a weekly report from deputy administrator Robert Seamans to the White House and the chairmen of the House and Senate committees that authorized the NASA budget. These reports were then spoon-fed to the press as the official version of events. As for any discussion of whether to conduct



the investigation internally or externally, “there was absolutely none as far as I was concerned,” Seamans says today. “I assumed we were going to follow our own guidelines.”

The eight-man review board, consisting of six NASA people, one Air Force colonel, and an explosives expert from the Bureau of Mines, produced an abstruse 3,000-page study that had much in common stylistically with military accident reports. According to Seamans, it tapped the efforts of 4,000 to 5,000 people. The final list of 11 “findings, determinations and recommendations” came down hard on North American Aviation, manufacturer of the capsule, charging that “deficiencies existed in Command Module design, workmanship and quality control.” These faults “created an unnecessarily hazardous condition and their continuation would imperil any future Apollo operations.”

But the Apollo investigative board had skirted the most obvious problem on Pad 34 that awful January evening. Following a NASA procedure that dated back to Project Mercury, technicians had pressurized the capsule with pure oxygen at 16.7 pounds per square inch. In this exceedingly flammable environment, there was no way to make the capsule fireproof. The tiniest spark would instantly set off an inferno.

The final report did not even recommend halting this procedure. Number nine on the list of 11 findings noted that “this atmosphere presents severe fire hazards if the amount and location of combustibles in the Command Module are not restricted and controlled.” It then kicked a classic bureaucratic punt

Regan made the first move.



by suggesting that "studies of the use of a diluent gas be continued with particular reference to assessing the problems of gas detection and control and the risk of additional operations that would be required in the use of a two gas atmosphere." In other words, appoint another committee. (A safe two-gas environment was adopted before the next manned flight.)

"I feel that it was a directed verdict," says Lee Atwood, then-president of North American, about the Apollo investigation. Atwood, now retired in Los Angeles, was deeply branded by the tragedy, as were a number of top Apollo engineers of the day. Twenty-one years after the fire, Atwood self-published a small pamphlet that reviewed the episode, opining that "the decision by President Johnson to have the inquiry done internally by NASA was probably a major factor in allowing the program to continue promptly in relatively good order. Since the assassination of President Kennedy, the schedule for completing a lunar mission within the decade had become, symbolically, nearly as important as the program itself. There was not time for extended testimony, redesign and retracing decisions."

"I really think that the true facts about oxygen exposure were aired and considered, and NASA management

more or less declined to take any responsibility for the problem," Atwood says today.

Buz Hello, who left a non-Apollo job at Martin Marietta after the fire to direct all North American operations at Cape Kennedy, remembers how the workers reacted. "The smaller people down the line felt that they had been unfairly put upon by NASA. It was NASA's decision to fill the cabin with pure oxygen, and—to listen to some of the lower people at North American talk—this was done against the advice of North American. Webb was just tyrannical. People who sat in on flight readiness meetings [after the fire] asked questions of the contractors in an entirely different, it'll-never-happen-again way." NASA's relationship with its contractors—which had frequently been adversarial—stiffened even more. "It was extremely painful and embarrassing to a very proud company," says Hello.

Both Webb and Seamans vehemently deny that NASA management manipulated the findings, though Seamans believes that NASA bore responsibility for "missing the point" about the danger of an all-oxygen cabin. He concedes today that the absence of a blunt order to junk

the all-oxygen system is "a valid point" of criticism of the report.

Congress also launched an investigation. Senator Walter Mondale, the most vocal critic of the costly glamour of manned spaceflight, exposed a memorandum that sent tremors through NASA. (The document's existence had been suggested to Mondale by ABC television reporter Jules Bergman.) Dated more than a year before the accident, the memorandum harshly criticized North American's performance on Apollo contracts. Written by Apollo program director Sam Phillips, the memo summarized a plant inspection that "confirmed beyond any doubt all previous indications we have had that the Apollo Program is severely jeopardized by this contractor." The NASA accident report mentioned nothing about such loud forewarnings.

"When I asked Webb about it, you should have seen the look on his face," Mondale recalls today. "It was clear to me that this was the one thing they didn't want to happen. Webb came to me after the hearing and asked if I had permission to ask about the Phillips report. 'You should know enough to ask the chairman of the committee before you ask a question like that,' he said. 'I'm a Democrat and you're a Democrat.'" (Chairman of the Senate committee on aeronautical and space sciences—which had been set up by Lyndon Johnson—was Democrat Clinton Anderson of New Mexico, a staunch supporter of NASA.)

One upshot of publicizing the Phillips report was that Webb chewed out Seamans for volunteering information, "on the basis that 'millions of dollars were at stake and you don't want to answer any question unless you're asked,'" according to Seamans. If this attitude even partially trickled down to NASA's internal investigation, it would not be surprising that there were questions about its thoroughness.

Mondale believes that within NASA there was a "suppressed, bitter debate about the pure-oxygen environment." But whatever political flames were fed by the capsule fire, all were extinguished by the sheer momentum and dazzling success of Apollo. For all its earnestness, NASA viewed the investigation as a two-month hiatus in its

moon-bound journey. Though the project ended up slipping 18 months behind schedule, it still met JFK's quasi-sacred deadline of landing a man on the moon by the end of the decade.

The moon landing may have been temporarily sidetracked by the internal investigation, but the shuttle program was completely derailed by an outside investigation. Three years would pass before the shuttle flew again. And instead of its former status as sole-access-to-space, it was drastically downgraded to special projects only.

In comparing the fallout from the Apollo and shuttle accidents, it is clear that the personalities of the respective NASA and White House administrations were significantly different, but the missions themselves mirror how NASA had changed in the two decades that separated Apollo 1 and the *Challenger*. Most of the people from NASA and industry interviewed for this article believe that the manned space program had become far more fragile by the 1980s. To some observers, the shuttle had become a perfect symbol of the way NASA had lost direction after the moon landing—it had become a spaceship without a destination. Viewed from this perspective, it was the shuttle's tenuous position that necessitated the consensus-building of a presidential commission.

The commission that was appointed had in common with the shuttle program a public relations mentality. The 11 members included such household names as Neil Armstrong and Sally Ride, who were not only qualified but also celebrities. Unlike the technical language that had characterized the Apollo investigation, the *Challenger* inquiry produced a glossy report. Its tone was remarkably genteel compared with the Apollo findings.

Morton Thiokol, manufacturer of the solid rocket booster that exploded, came under intense scrutiny. But regrouping after the *Challenger* explosion was more involved than the Apollo 1 aftermath, when people were quickly axed. Most managers in sensitive positions at both NASA and Morton Thiokol were either reassigned or allowed to retire quietly. The lack of any criminal indictments led Senator Ernest Hollings, chairman of the Commerce, Science and

Transportation Committee, to demand that "every single [guilty] person be identified and disciplined."

This was the only notable squawk heard from Capitol Hill during the whole *Challenger* episode. Some NASA veterans, however, think the Rogers Commission left too many questions unanswered. "To this day, I don't know who's at fault—Larry Mulloy or the people at Thiokol," says James Fletcher, who took over from Graham as NASA administrator, referring to NASA's solid rocket booster program manager. During his first tenure as administrator in the 1970s, Fletcher had been responsible for many of the shuttle program features blasted during the *Challenger* investigation. He believes NASA should have been able to clean its own house after the *Challenger* explosion. Fletcher resented the incursion into what he saw as NASA turf, telling the *Orlando Sentinel* when he retired in April 1989 that "we [at NASA] get



the facts much quicker, and the person, if he's guilty, is removed."

"Many of the people in NASA from the Apollo era were very critical of letting the [*Challenger*] investigation get outside," William Graham says today, "but I think the ultimate question is 'Do you want the heads of agencies to have a no-fault insurance policy, so that whatever they do, they control the subsequent investigations of difficulties?' I think the answer is that that's not good public policy."

Graham is fully aware of the contrast

between his handling of the investigation issue and Webb's. Unlike Webb, Graham had only an interim finger-hold on the administrator job, and he was aware that certain NASA executives still close to former administrator James Beggs were acting to subvert his authority. Beggs had taken a leave of absence in late 1985 under the shadow of a federal indictment for contracting fraud at General Dynamics (the Department of Justice later abandoned the case), but he continued to show up at NASA headquarters. After the *Challenger* disaster, Beggs went so far as to come to Graham's office with an unsolicited list of members for an internal investigative panel. "One view of NASA is that it's an independent empire," Graham observes. "My view is that it's part of the administration."

Commission chairman William Rogers, a lawyer whose credentials as a loyal Republican stretch back through service as Richard Nixon's Secretary of State to Dwight Eisenhower's Attorney General, was hand-picked by Don Regan. Rogers says that he received no instructions or advice from the White House before starting the proceedings, which suggests that the president's staff felt confident that they had a team player in charge. Rogers cites the lack of second-guessing by Congress and the press as the strongest evidence of the panel's thoroughness.

The final word on both tragedies, as well as an admonition for the future, may belong to Richard Feynman, the Nobel physicist who served on the *Challenger* commission. Feynman "wasn't a team player," according to Rogers, but an "iconoclast" whose now famous experiment with a glass of ice water to demonstrate how the O-ring seal had failed annoyed the commission chairman. Nonetheless, the earnest professor from the California Institute of Technology, who died of cancer in February 1988, provided the most candid insights: "Let us make recommendations to ensure that NASA officials deal in a world of reality, understanding technological weaknesses and imperfections well enough to be actively trying to eliminate them," he wrote. "For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled." ➔



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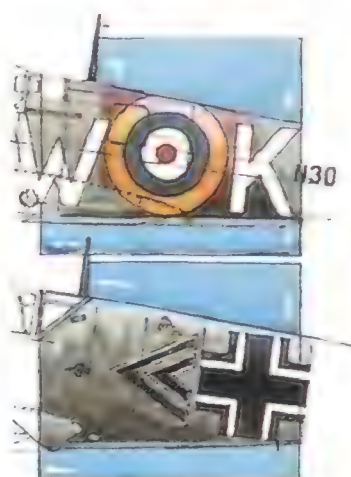
Illustrations by Ken Dallison

Sunset on Adlertag

Göring told them it would be easy.
Today, Luftwaffe survivors remember
only remorse and frustration—
and that Göring was wrong.

Not every nine-year-old has the privilege of seeing the front of his house fall off. I was so favored one bright blue morning in the late summer of 1940. We lived in southeast London, just a few miles north of the Fighter Command airfields at Biggin Hill and Kenley. The day before, a bomb had arrived in our front garden, courtesy of the Luftwaffe, and had carved a large hole. It had been the last of a long stick of bombs that had torn ugly gaps in the rows of houses farther up the street. Our bomb, however, had simply lain beneath the flower beds and ticked away, the blind black eye of its passage staring into the brilliance of the morning.

It was early, but the first raid of the day was already in progress. Bedding in hand, I was walking toward the fragile security of a neighbor's house. The local anti-aircraft batteries were firing, and a large formation of Dornier 17s rumbled overhead, aimed at London's docks. At that instant the bomb in our garden blew up. The explosion numbed the senses. My lungs seemed empty and I gasped for breath. From 50 yards away, I watched the ordered solidity of the front wall of our house collapse slowly, agonizingly, into rubble. I looked up and saw that the Dorniers were now being engaged by Hurricanes. I imagined myself in one of those cockpits, an avenging angel for our wounded house. In that moment, I knew that I would join the Royal Air Force.



The Battle of Britain:
50 Years Later
Second in a Series





Fifty years later, a full and rewarding RAF career behind me, I have come to know some of the airmen who flew the Luftwaffe aircraft I saw overhead back in 1940. I am not alone in this; members of both sides of the Battle of Britain have long since made their own peace and have come to know each other. They meet fairly regularly, drawn together by the shared experience of a titanic struggle. When they gather to relive those desperate moments of their youth in the skies over southeast England, inevitably their hands will begin to twist and roll; they are, after all, pilots.

Their epic battle still exerts a powerful pull on me, and earlier this year, which marks the 50th anniversary of their struggle, I went to Germany to meet some of the men who had so profoundly influenced my life. I found myself knocking on doors I would never have approached when I was a boy.

In the picturesque town of Marburg in the central part of West Germany, I found an ebullient Wolfgang "Bombo" Schenk. Now comfortably retired, Schenk had flown twin-engine Messerschmitt 110 fighters during the war. He laughingly suggested to me that given the circumstances, England's stubborn refusal to negotiate a peace had been quite irrational. But just behind his smile, I sensed, lay an honest conviction that his opinion was entirely justified. Many of the Luftwaffe veterans I met with told me that in 1940 they had been surprised to find themselves fighting the British at all. Once, as he complained to me that the Luftwaffe's fighters and bombers could not communicate with each other by radio, Schenk noted with some irony that he and his fellow fighter pilots could occasionally talk to the RAF. He recalled radioing, "I am sorry we are fighting. The German and British people should be brothers." The response, he remembered, was invariably pithy.

In 1940 Edu Neumann was flying Messerschmitt 109s with fighter group JG27. After the war he became a successful businessman and now lives in Munich. We met over a Bavarian lunch, and Neumann, courteous and gentlemanly, remembered the ferocious fighting with a tinge of sadness. I was particu-

larly struck by his recollection of something an old-style German officer had said to him before the war. "It will be a very terrible thing if we fight the English," the officer said. "They are people like us."

Facing the White Cliffs across the Channel, the Luftwaffe's airmen may have felt that the British were being unreasonable, but Germany's air force was sure it could meet the challenge. Messerschmitt 109 pilots were especially confident. They had experienced leaders and what they believed to be the world's best fighter—the Bf.109.

Gerhard Schöpfel is a small, quietly spoken man whose mild manner belies his record of prowess as a fighter pilot. In the summer of 1940 he had served as the commander of III/JG26, a fighter squadron based in the Pas de Calais. As we sat in his apartment not far from Cologne poring over his collection of wartime photographs, he said, "We had had a few losses in France, but we were young and we did not think the fight against the British would be long." German aircrew taken prisoner then were not too concerned, he said. Most thought they would be back with their squadrons in a month.

Fritz Losigkeit, another JG26 pilot, told me, "After Dunkirk, a captured British soldier said to me, 'You won the battle, but we'll win the war.' We laughed."

Reichsmarschall Hermann Göring's *Adlerangriff* (Attack of the Eagles) battle plan called for an air campaign of only two to four weeks in preparation for a cross-Channel invasion that he believed would be nothing more than an unopposed occupation. Elated by a string of remarkable victories on the Continent, the Luftwaffe's few misgivings were eclipsed by a general sense of self-confidence.

Göring chose August 13—*Adlertag* (Eagle Day)—to launch his grand plan. The day before was set aside for some softening-up attacks on the forward RAF airfields and on the puzzling but prominent arrays of radar antennas that lined the English coast. The operations conducted by the Luftwaffe on August 12 and 13 and the interpretation of the results were in many ways typical of the campaign. During these two days, the essential elements of the Luftwaffe's failure were already evident and having their effect.

Many of the Luftwaffe veterans told me that in 1940 they had been surprised to find themselves fighting the British at all.

The German forces pressed home the attacks of August 12 with determination. Luftwaffe bombers dropped heavy concentrations of ordnance on every targeted airfield and radar station. Jubilation at the post-raid reports was qualified only by the news that the German radio listening service had noticed that the breaks in transmissions from the radar sites had been few and disappointingly brief. The Luftwaffe staff drew two conclusions from all this. They judged the radar stations to be unprofitable targets and gave them a low priority for future attacks. However, the airfield raids were thought to have been

wholly effective. In fact, several crucial radar sites had narrowly averted disaster, and although the airfields had been heavily damaged, crews filled cratered runways, patched buildings, and for the most part had the fighter stations back in action within 24 hours.

Adolf Galland is perhaps the Luftwaffe's best known surviving ace. He has become a renowned figure among aviation historians in the years since the war ended. His book, *The First and the Last*, is a fighter pilot's classic. A genial man who has become great friends with his former enemies, he has always had the courage to speak his mind. He did so most recently last spring when he joined his former adversaries in Washington, D.C., to remember the summer of 1940. His views on the quality of the Luftwaffe staff's intelligence work

are of great interest to historians, and Galland's opinions have not mellowed over the years. As on previous occasions, I heard him offer some scathing comments on the Luftwaffe's commanders and headquarters staff.

"Göring was not interested in radar," he says, throwing his hands up in despair. "For us radar was a surprise and a very bitter one." As for the airfield attacks, Galland is still appalled that the Luftwaffe staff could be so misguided. "At Luftwaffe HQ," he says, "somebody took the reports in one hand and a thick blue pencil in the other and crossed the squadron or base off the tactical map." The Luftwaffe staff came to believe that entire RAF units had been taken out of action.

Galland is equally forthright about the Luftwaffe's poor intelligence assessments of Britain in general and of the RAF







in particular. The Germans intended to target fighter bases on *Adlertag*, but many of the airfields on the target list did not even belong to Fighter Command—they were bomber, maritime, or training airfields. The Luftwaffe also listed aircraft factories as primary targets, but they were often misidentified, and Göring's staff altogether missed the significance of the Spitfire factory near Southampton (a city nonetheless bombed for other reasons during the campaign).

Flawed estimates of RAF Fighter Command strength helped seal the fate of Göring's plan. In early July, the Luftwaffe slightly overestimated the number of RAF front-line fighters but badly underestimated aircraft production rates. By the middle of August, relying on exaggerated claims of German victories (both sides were wildly off in their estimates of each other's losses), the Luftwaffe told its squadrons that Fighter Command had been reduced from more than 700 serviceable aircraft to approximately 300. In fact, there were more than 850 aircraft in the front line.

Although at first encouraging, the Luftwaffe staff's daily predictions of an early victory were soon discredited, and the continued appearance of large numbers of RAF fighters steadily eroded German aircrew morale, particularly in the bomber and Stuka squadrons.

Many Luftwaffe veterans cite the lack of contact between the German fighter and bomber units as a key organizational flaw. Having no radio communication tended to foster an "us and them" attitude and led to a great deal of mutual misunderstanding. As the bombers' losses mounted, so did the recriminations.

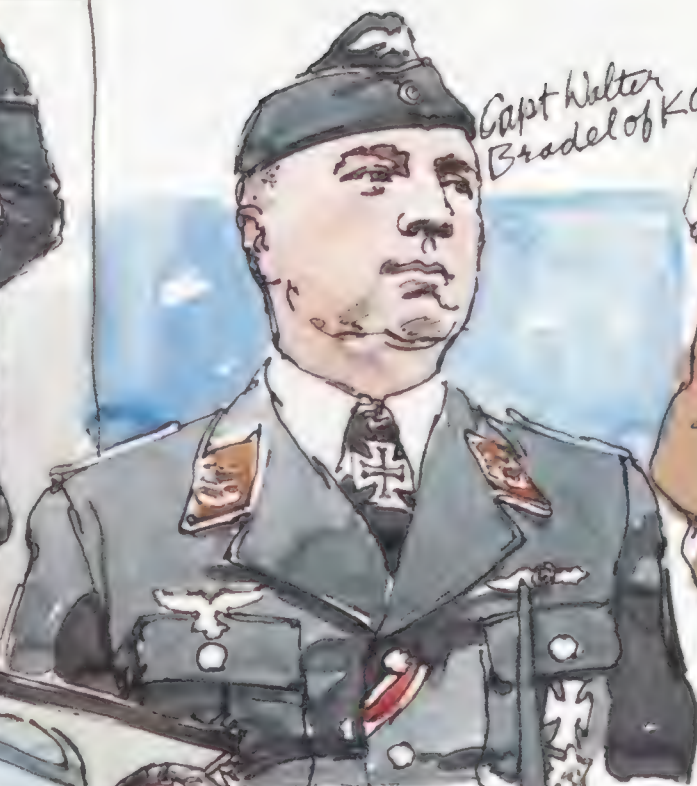
The point was driven home when I spent a morning with Heinz Lange, a charming and thoughtful man now comfortably retired from a career in insurance and banking. In 1940 he was a Bf.109 pilot with JG54, a fighter group based near the Channel coast. Shaking his head in dismay, Lange told me, "We had no contact with the bombers before, during, or after a raid." Like Schenk, however, he'd managed to speak to his enemies. "Oddly enough, we did sometimes manage to speak to the RAF in the air. They usually replied by calling us 'damned bandits' or 'huns.'"

Hajo Herrmann, celebrated as the man who organized the Luftwaffe's elite "Wild Boar" night fighters later in the war, is today a tall, imposing figure with an elegant beard. Herrmann was a bomber pilot when the campaign against Britain began, and he recalled "a very rigid system in which we could not talk to the fighters. We were briefed to fly routes and times and told that the fighters would be there, not to worry if we did not see them. We never knew if they were really there and we did not think the Me.109s always provided adequate protection."

Göring's beloved Messerschmitt 110 *Zerstörer* (Destroyer) was of little help to the long-suffering bombers. Designed as a long-range escort fighter, the lumbering twin-engine Bf.110 proved so vulnerable to RAF fighters that a squadron under attack would form a huge circle, each aircraft covering the one ahead while the leader tried to find a way of maneuvering the formation in the direction it needed to go. The ultimate lunacy came when Göring insisted that 110s always be accompanied over England by the faster single-engine 109s. "The young pilots laughed at Göring and his love of the *Zerstörers*," Fritz



1st Lt Hans & Bob
of JG 54



Capt Walter
Bradel of KG 2



Oberst
Werner
Moelder

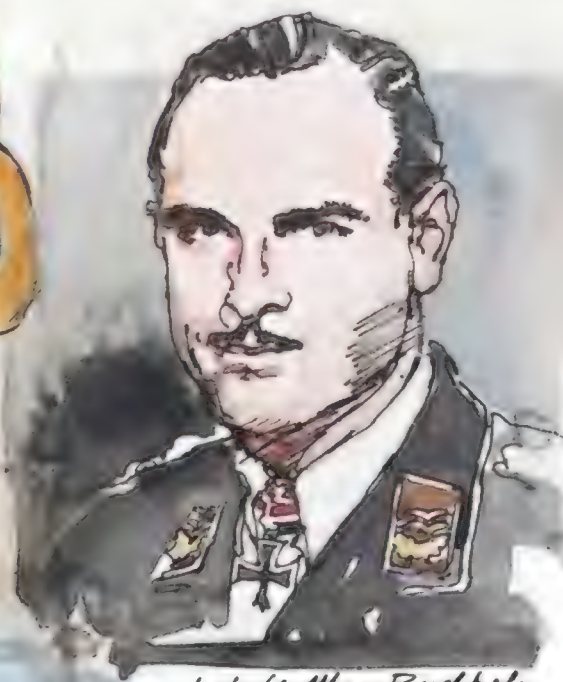


Maj Helmuth

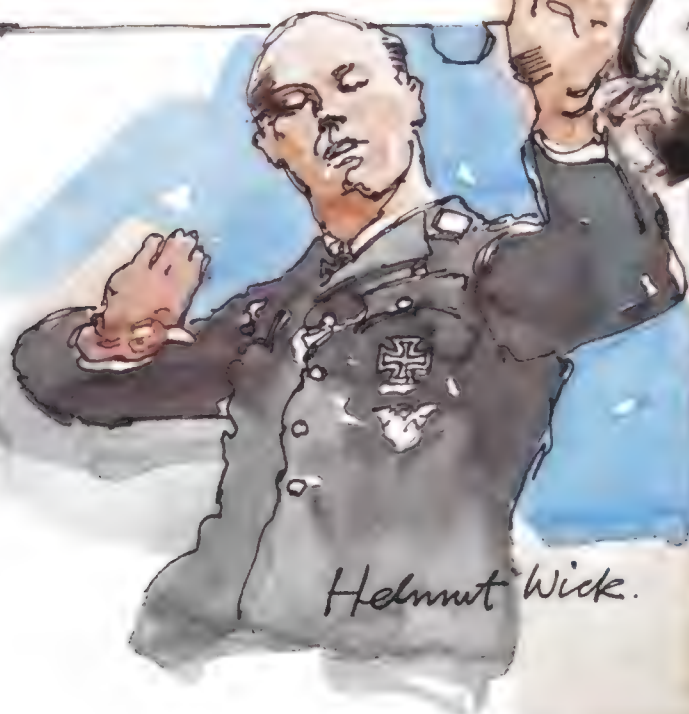
1st Sgt Heinz Bahr
of JG 51



Adolf
Galland



1st Lt Max Buchholz
of JG 3



Helmuth Wick



Joachim Müncheberg

Losigkeit recalled. "We saw them circle quite often. Once, near Dungeness, I saw a great many locked in a circle because of two Spitfires."

In other roles, the Bf.110 was more successful. When Schenk joined the experimental combat unit *Erprobungsgruppe* 210, formed to develop new tactics, he was sure that the 110 could be effective as a fighter-bomber. His nickname, "Bombo," attests to his success. His voice was full of pride as he told me of his achievements with the aircraft. "The Stuka supporters fought me over this," he said. The Junkers Ju.87 Stuka dived on its target vertically, and it was accurate but too slow. "I was completely opposed to their concept of operations," Schenk said. "I believed that we should attack targets in shallow dives, downwind, at full throttle and with no dive brakes. We relied on speed rather than a vertical dive, and went over the target at about 450 mph. We were just as accurate as any Stukas."

As the battle intensified in the days after *Adlertag*, it was the Stuka squadrons that suffered most. I heard something of their ordeal when I called at Kurt Kuhlmeier's house in a quiet corner of Bonn. Kuhlmeier flew the Stuka on every front during the war and became recognized as an outstanding leader. He thought the airplane was most effective when flown in support of ground operations but inappropriate for a strategic campaign. He remembered the Ju.87 as "a very strong and reliable aircraft and an accurate dive-bomber, but it was much too slow. And the single rearward-firing machine gun was not very effective against an eight-gun fighter. When we were attacked by Hurricanes, we were completely dependent on our fighter escort."

Surrounded by model aircraft, squadron badges, and nostalgic photographs in the paneled basement of his home, Fritz Losigkeit was emphatic in his assessment: "The Ju.87 squadrons were by far the worst to escort." Much as he disliked the job, however, he would not have exchanged his Bf.109 for Kuhlmeier's Stuka.

Heinz Lange agreed, explaining that the Messerschmitt 109, lacking dive brakes, accelerated quickly and could not accompany the Stuka throughout its dive. To cover an attack, said Lange, "some fighters had to stay above the starting point [perhaps 12,000 feet or more] and others waited below, nearer the height of bomb release [about 2,000 feet]."

These precautions were not successful, and it became known that Hurricane pilots looked forward to the opportunity of joining a "Stuka party." In the six days of operations following *Adlertag*, the Stuka groups lost 42 aircraft and sustained damage in another 14; some returned with dead or wounded crewmen. On the evening of August 18 a Stuka commander climbed out of his battered aircraft and commented, "They ripped our backs open right up to the collar." Göring, horrified, blamed the escorting fighters for the losses, claiming they had not shown enough aggression in defending the bombers. However, he withdrew his idolized Stuka groups (some 280 aircraft) from the battle "to conserve them for the invasion."

Galland has said, "Both the Ju.87 and the Me.110 were misconceived, and the Me.110's limitations in particular should have been revealed in exercises before the war." He adds that not just the machines were at fault: "More than once, the bombers arrived late and the fighters joined another

bomber formation which had already met its escort and thus flew doubly protected, while the belated formation had either to turn back or make an unescorted raid, which usually resulted in heavy losses."

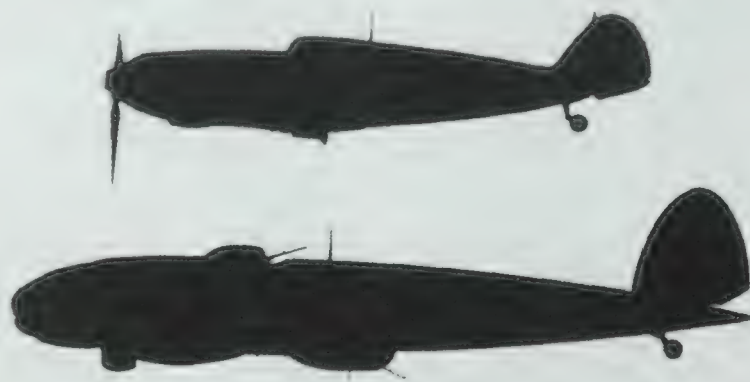
Mistakes like that did not encourage the bomber crews to believe that the fighters were "really there" even though they might be sweeping ahead or covering the bombers from high above and into the sun to gain the tactical advantages so vital to fighter pilots. Complaints of inadequate fighter protection eventually reached Göring, further angering him. "He had nothing but reproaches for the fighter force and expressed his dissatisfaction in the harshest terms," Galland recalls. "Göring clearly represented the point of view of the bombers and demanded close and rigid protection."

Schöpfel, Neumann, and Losigkeit all remembered with distaste the order to fly close to the bombers and not break

The Luftwaffe's Front Line

The Bf.109 fighter (top) had the distinction of serving the Luftwaffe throughout the entire war, but as Germany's front-line fighter, it played an especially important role during the Battle of Britain. Developed in the mid-1930s by the Bayerische Flugzeugwerke, the fighter is often identified as the Me.109 after Messerschmitt, the company that succeeded BFW. The 109 was state-of-the-art: it combined all-metal construction with retractable gear and leading edge slots to maintain airflow over the ailerons near the stall. Fitted with a Daimler-Benz DB 601N engine rated at 1,200 horsepower, the 109E series made a formidable opponent. This inverted-V engine employed fuel injection and, unlike the RAF's Merlin, was immune to power loss in negative Gs. The 109 normally carried two 20-mm cannon as well as two machine guns.

The Heinkel 111 bomber, employed heavily in the Battle of Britain, began life in 1936 masquerading as an airliner to hide its true purpose. The bomber version soon emerged, and the H series employed in 1940 carried five or six crew members and 4,400 pounds of bombs along with varying arrays of defensive guns and protective armor plate. Its two Junkers Jumo 211 engines were rated at 1,200 hp (earlier versions had DB 601s). The 111's most distinctive features were the generous glazed area in its tapered nose, a truncated vertical fin, and a unique reverse taper at the wing roots. It was a versatile airplane, serving as a torpedo bomber, a missile launcher, and, near the war's end, once again a transport.





formation and fight unless directly attacked. "It was very difficult to fly close escort at the bombers' height," Heinz Lange explained. "The Spitfires came from high above, so we could not afford to fly at the same speed as the bombers."

Medium bombers—Heinkel 111s, Dornier 17s, and Junkers 88s—carried the main weight of the assault on Britain. The most heavily employed was the Heinkel 111, flown for a while by Hajo Herrmann. Stroking his beard, Herrmann described the 111 as "having poor defensive armament. Single guns were no match for a Spitfire's eight." Still, he found it "a pleasant machine to fly, reliable and very strong. I have seen a Heinkel get back to base after being hit over 200 times."

Pressed to tell something of his own battle experiences, Herrmann held me spellbound with a story that illustrated his legendary determination and his remarkable capacity for survival. It happened in a Ju.88 during a night mission to lay mines in Plymouth Harbor. "I approached the harbor from the northeast, throttling back to let down from 16,000 feet with air brakes out, flying just above the stall. I could see the port clearly outlined in the moonlight. Suddenly, as I approached my target, a huge shape loomed up in front of the aircraft. I struggled to avoid it but it was too late. The next instant the aircraft squashed into the top of a barrage balloon and we lost speed as it enveloped us." Ju.88 and balloon merged and swung together through the night sky. To Herrmann's surprise, "our engines continued to run without piercing the balloon, and eventually, all flying speed gone, we fell off. I noticed searchlights shining from above and realized we were upside down and out of control. I felt like a man playing a piano which had fallen from a high building."

Herrmann ordered the crew to bail out. The escape hatches were jettisoned, but before anyone left the aircraft, the nose came down, the speed increased, and Herrmann leveled the Ju.88 low over Plymouth, pointing at the harbor. Ignoring the searchlights and the fire of the now thoroughly alerted anti-aircraft defenses, he hung on to drop his mines before escaping into the darkness.

Without exception, pilots in units equipped with the Bf.109 felt good about the fighting capabilities of their aircraft. "We were confident the Me.109 was superior to the Hurricane and that it was at least a match for the Spitfire," said Heinz Lange. "We were better when climbing or diving, although I think both the RAF aircraft were more maneuverable. We were better armed, with 20-mm cannon, and there was no doubt

about the superiority of our fuel injection system over the carburetors of the Rolls-Royce Merlins. We could push over into a dive without the engine faltering."

Gunther Rall, his 275 victories making him one of Germany's greatest aces, said, "The Me.109's guns were good, but in most models they were grouped tightly together in the nose. This meant there was very little spread of shot, so shooting had to be accurate." I asked if firing the guns would fill the cockpit with smoke. "If you do it right," Rall replied, "the other guy gets smoke in *his* cockpit."

Galland has analyzed the way the aircraft were flown. "The British were at a considerable disadvantage because of their close formation," he says. Since its experiences fighting for Francisco Franco in the Spanish Civil War, the Luftwaffe had been flying a loose combat formation based on the four-aircraft *Schwarm*, consisting of two supporting pairs, or *Rotte*. "I was surprised to find the RAF so inexperienced," said Fritz Losigkeit. "They had a lot to learn about tactics." Heinz Lange agreed. "We often saw the RAF fighters handicapped because they flew in close formations of three," he said. Almost apologetically, as if afraid to offend his British guest by suggesting that the RAF had ever been found wanting, Gerhard Schöpfel told me how he had taken full advantage of this over Kent on August 18.

Schöpfel was leading his squadron on a fighter sweep when he saw below him "Hurricanes, flying in close formation of

**"We saw just as many RAF fighters each day,
and we thought about how many were shot down
and got back in the fight. Ours did not."**

threes, climbing in a wide spiral near Canterbury." Placing his squadron into the sun, Schöpfel opened the attack himself, leaving the other 109s to cover him from above. He was betting that the RAF pilots would find it difficult to pick up a single aircraft. "Two Hurricanes were weaving behind, covering their formation. I dived down alone and they did not see me. I got very close before firing and shot both down in rapid succession. Then I attacked the rearmost Hurricane in the main formation, and it too went down. The British pilots had still not noticed anything so I moved on to a fourth. This time I got too close, perhaps only 20 meters, and pieces of the Hurricane damaged my aircraft, so I had to leave." Schöpfel had destroyed four Hurricanes in less than two minutes.

Encounters with Hurricanes were not always so easy. During our lunch in Munich, Edu Neumann recalled one occasion when an explosion shook his 109 while he was firing at Hurricanes coming at him head-on. A very large hole ("It would have taken two men with joined hands to get their arms round it") appeared in the middle of his starboard wing. At much reduced speed, Neumann sought the safety of a low cloud layer and worked his way toward the Channel. As he did so, he heard a young German pilot calling plaintively that he was alone and did not know what to do. Neumann answered immediately:

"Fly east! Fly east!" Then he heard the voice of another Luftwaffe pilot: "Just wait. A Spitfire will be along in a minute and then you will be alone no longer." Doubtless encouraged by this thought, both Neumann and the newcomer made it back to base to fight another day.

For all its admirable qualities as a fighting machine, the Bf.109 had one serious drawback: it didn't carry enough fuel. Running short was so commonplace that the standard response to a young wingman reporting that his low-fuel warning light had come on was "Well, cover it up." Such a drawback seriously hamstrung the Bf.109 as a bomber escort. Since it was too hazardous for bombers to fly over Britain by daylight without a Bf.109 escort, the fighter's limited range restricted the reach of Luftwaffe bombers. Even operating from airfields near Calais, France, the 109, once it was over London, could engage in only a few minutes of combat before low fuel forced it to head back.

Heinz Lange sighed as he told me how he sympathized with the bombers. "They always had to take the shortest and most predictable route to their targets because of our range," he said. "We operated from as close to the French coast as possible, but even so we lost a number of fighters in the Channel after they ran out of fuel."

Gunther Rall emphasized that the 109's limitations guaranteed that 90 percent of Britain would be protected from daylight attack. Outside a very small area in southern England, the RAF could rest its squadrons, train new pilots, and have new aircraft built. Had the Luftwaffe High Command provided the 109 with a jettisonable external fuel tank in time, the bombers could have been much more effective against the British.

Heinz Lange agreed that extra fuel for the 109s might have changed the battle, but then he smiled and added, "It was perhaps a good thing that the extra tanks came later. We did not have to stay so long over England."

As the summer wore on, the intensity of the air battles showed no sign of diminishing. Rattled by the RAF's continued resistance and goaded by Hitler's anger at bomber raids on Berlin, Göring arrived in France on September 7 to take personal command of the battle and shift the focus of the assault to London. Except for the fact that almost every raid would now be conducted at the limit of the Bf.109's range, this meant little to the Luftwaffe squadrons. None of the pilots I talked to could remember being given any explanation for the change in strategy, and it seems that very few airmen gave any thought to the possibility that ending direct attacks on airfields would give Fighter Command the opportunity to gather new strength. The Luftwaffe pilots' horizon was limited to the challenge of the next trip across the Channel, day after day, with no end in sight. "By mid-September the strain was beginning to tell," recalled Edu Neumann. "Many pilots were suffering from *Kanalkrank* [Channel sickness] between sorties."

The Luftwaffe conducted its assault against London with massive fighter escorts—often three times as many fighters as bombers. Göring was quite sure that Fighter Command had been reduced to fewer than 300 aircraft, and he proposed to overwhelm this remnant with raids employing more than 1,000 aircraft. The Luftwaffe crews were again told that the RAF was nearing its last gasp. On August 8, 1940, a few days

before the bomb arrived in front of our house, Göring had issued an Order of the Day to the Luftwaffe that included the remark "Within a short period, you will wipe the British air force from the sky." That conviction would be repeatedly expressed during the following weeks.

"We found that difficult to believe," Gerhard Schöpfel recalled. After 50 years he still sounded exasperated at the blindness of the staff officers and disillusioned by the fading promise of swift victory. "We saw just as many RAF fighters



each day, and we thought about how many RAF pilots were shot down over their own country and got back in the fight. Ours did not."

In the massive air battles of September, the pattern was continually repeated. No matter how many RAF fighters were claimed shot down, the next day the Luftwaffe was invariably confronted with more. "We laughed at the reports from HQ," Heinz Lange said. "We could not take them seriously. The losses mounted, doubts began, morale slipped, but the fighting did not slacken. Then, as the winter weather came, the battle





went to sleep. It seemed that we had lost a lot of good people for very little purpose."

They fought through 1940 with courage and perseverance, accepting battle in enemy skies, until both sides neared exhaustion. Now in the autumn of their years, these former combat pilots have a story to tell, but in their own country it has not been a popular one. They live with the irony that they are honored most by their former enemies. If, in the act of remembering, they express rancor, it is not directed at their old opponents, for whom they seem to have unreserved respect. "Both sides fought fairly," said Heinz Lange. "They kept respect for their enemy. Because of this, after the war they could meet each other and become friends."

Fifty years after the battle, it is the wartime leaders for whom the Luftwaffe veterans reserve their bitterness. "The commanders had no real insight into how to use the Luftwaffe," Hajo Herrmann told me. "The Luftwaffe was designed to support the army, not for a strategic bomber offensive." The best and brightest among them agree. "It was the opinion of the young squadron leaders that their leaders had taught them little apart from dancing and drinking," said Bombo Schenk. Even Adolf Galland, who would become Göring's General of Fighters, has said that complete victory over the RAF was probably beyond the capabilities of the Luftwaffe as it was then equipped.

Listening to such hardheaded and proficient airmen talk, I could not help feeling that, having done their best, they still regret not having done better. Individually among the most successful fighting aviators the world has ever seen, they are nonetheless forced to confront a harsh truth: their efforts produced a collective defeat.

That was not always so clear. When asked about the end of the battle, all of the Luftwaffe pilots I met said that they had expected to use the winter to recover their strength. All of them believed that the spring of 1941 would see them taking up where they had left off. They had no idea that Hitler was already studying maps of Russia. The sad recognition of failure had to wait. "We did not know we had fought 'the Battle of Britain,'" explained Fritz Losigkeit. "Those words came later." →





Nader's Air Raiders

For 20 years, the feisty Aviation Consumer Action Project has been scrapping with the giants, and lately it's been winning.

by David Savold

It was after an appearance on "The MacNeil/Lehrer News Hour" in 1980 that Con Hitchcock realized both he and the organization he works for had passed some sort of litmus test. As a representative of the then nine-year-old Aviation Consumer Action Project, he had been invited on the television program to talk about commuter airline safety. Hitchcock was chatting with the other panelists after the show when he was introduced to a representative from the airline industry and his wife. "I gotta say one thing," said the wife. "You Nader people all look alike, but you sure know a lot more than you did a couple of years ago."

These days, ACAP's founder, consumer advocate Ralph Nader, holds only a figurehead position, and the organization is run by two attorneys who, in fact, don't look anything alike. But Con Hitchcock and Chris Witkowski do fit the mold of what were once known as Nader's Raiders—bright young individuals willing to forego large salaries for the opportunity to work for the public interest.

In the nearly 20 years since Nader founded ACAP to look after the rights of airline passengers, the organization has moved slowly and not always steadily toward becoming an effective shaper of aviation policy. ACAP was among the earliest to call for the smoking ban on domestic U.S. flights that went into effect last February, fought to upgrade antiquated medical kits on airliners, and succeeded in pushing through a \$750 increase in the maximum reimbursement for lost luggage.

Every bit the shoestring operation,

A small budget keeps Chris Witkowski's office humble, but it doesn't limit ACAP's lofty goals.

ACAP doesn't bring in money by selling insurance, offering rental discounts, or relying on industry money. Its battle with government and industry on behalf of airline passengers is funded by individual donations totaling under \$40,000 a year (with some support from Nader's consumer advocacy group, Public Citizen). ACAP "really has very little assets and resources except for the energy of the people working there," says Reuben Robertson, an attorney specializing in savings and loan regulation who helped Nader start ACAP.

Hitchcock, formerly ACAP's executive director and now, at 38, its legal director, came to Washington, D.C., to attend law school at Georgetown University in the early 1970s. His work at a public interest law firm led him to ACAP. Witkowski, 36, is ACAP's executive director. He became interested in public policy at Thomas M. Cooley Law School, and that interest brought him from Lansing, Michigan, to Washington five years ago.

Depending on whom you talk to in the aviation field, this two-man force is everything from a highly useful organization to a highly irrelevant one. "ACAP at various points in its history has been both the useful gadfly and the shrill publicity hound," says Michael Levine, dean of Yale University's school of management and former chief of staff at the Civil Aeronautics Board. "It depends on which issue and which moment you want to discuss."

Many who place ACAP in the shrill category are reacting to the legacy of Nader. His detractors like to say that ACAP was Nader's revenge for getting bumped from an Allegheny Airlines flight in 1972. He responded with a lawsuit that contributed to the eventual CAB ruling holding airlines more accountable to passengers for overbook-

ing. In fact, ACAP had been founded in 1971, a year before the bumping incident took place.

"It came out of Pillai's ground-breaking book on the IATA [International Air Transport Association] cartel," Nader explains. *Air Net: The Case Against the World Aviation Cartel* by K.G.J. Pillai, one of the masterminds behind ACAP's inception and now a professor at the Temple University School of Law, became the rallying cry for a group of young lawyers who believed that passenger interests needed a stronger voice.

"They were early among the people recognizing that regulation had converted the industry into a cartel," says Alfred Kahn, professor emeritus of political economy at Cornell University and a former chairman of the CAB who is considered the architect of deregulation. The CAB, which was established as the Civil Aeronautics Authority in 1938 to regulate the routes and rates of the airlines, became one of ACAP's earliest targets. "We were asking why we should have a CAB, and it was regarded basically as heresy," says Reuben Robertson. "It was uncomfortable at the time."

Comfort, at least the literal variety, still eludes ACAP. In Witkowski's office, battered and mismatched file cabinets—army green, gray, beige—line one wall. His window opens on to an airshaft. In an office around the corner, Hitchcock has stashed his suitcase behind a chair whose stuffing is making a break for freedom. He is waiting for a call from the New York attorney general's office. Pan Am is suing the attorney general to enjoin New York from enforcing a deceptive-advertising law against the airline. If Hitchcock goes to New York to assist in the attorney general's defense, he will stay with a colleague's

relatives—ACAP's official policy for business travel.

The idealism this leanness implies impresses some more than others. "Chris and Con are very bright people and very good at what they do," says Air Transport Association spokesman Stephen Hayes. "But you know we've got a staff of 140 people here. The airline industry has 500,000 employees and . . . to think that two people in a consumer action program would have that capability is—it's not a criticism, it's just to suggest that they just don't have the resources to really get into the kind of depth that we think you need."

"You either need money or votes," says Patricia Goldman, a former National Transportation Safety Board member and now senior vice president of corporate communications at USAir. "And they haven't had either."

Nader himself acknowledges the benefits of money and size. "If anybody comes in with a big contribution," he says, "I'm sure ACAP will be more effective because it will have more staff."

But Robertson believes the organization should not be judged on legal victories alone. "One of the things that ACAP tries to do as opposed to win a victory every time is at least raise public consciousness," he says.

Often it takes a tragedy to focus public interest on safety issues. "One of the things I always find frustrating is that when there's a crash—take Sioux City [the 1989 crash of United flight 232 near Sioux City, Iowa]—and all of a sudden infant seats are the rage," Hitchcock says. "I start getting calls from journalists around the country saying, 'How come anybody hasn't done anything about this?' I say we've been trying to raise consciousness on this issue for five or six years but without much success. Rulemaking petition was filed in 1983, and here it is 1990 and the FAA [Federal Aviation Administration] is saying that it needs to look at the problem."

One ACAP concern that has ignited public interest involves a group of individuals whose lives became intertwined when a terrorist bomb blew up Pan Am flight 103 over Lockerbie, Scotland. A few weeks after the December 21, 1988 explosion, Witkowski got a call from a man whose 16-year-old daughter had been aboard the flight. He invited

Witkowski to the memorial service in Syracuse, New York, to talk to several families who were interested in establishing a network to stay in touch. "It was very moving," Witkowski says. "It was a very rough time for the families."

The meeting led to the formation of Families of Pan Am 103 Lockerbie, which has gone on to establish a strong presence on Capitol Hill. Witkowski initially shepherded the families around the Hill and explained the byzantine ways of Washington to them. "We always rely on him for information that we don't have quick access to," says Rosemary Wolfe, a member of the board of directors for the Lockerbie group whose daughter was on the Pan Am flight.

Together, ACAP and the Lockerbie group submitted proposed rules to the FAA to help tighten aviation security. The collaboration also prompted the formation of the Presidential Commission on Aviation Security and Terrorism, which last May reported serious flaws in the aviation security system and criticized the FAA for poor enforcement of its rules.

ACAP and Families of Pan Am 103 Lockerbie have also pushed the FAA and the Department of Transportation to require airlines to notify passengers in the event of terrorist threats. Success has been limited, but Delta and

ACAP founder Ralph Nader set the tone for the organization by taking on a series of industry giants.

UPI/BETTMANN NEWSPHOTO



Northwest now voluntarily alert ticket-holders when their flight has been threatened.

ACAP's advocacy has earned the group its share of foes. "Do you want them alphabetically or chronologically?" Hitchcock asks. One of its most frequent adversaries is the FAA, which takes a guarded public stance toward ACAP. "Since they're not technical experts, they're not aviation professionals in the technical sense of the word," says Tony Broderick, head of public affairs at the FAA. "They're not really members of the aviation community. They are representatives of people who use airline services."

Not surprisingly, ACAP is frequently thwarted in its dealing with the FAA. Donald Engen, who was FAA administrator from 1984 to 1987 and is now president of the Air Safety Foundation of the Aircraft Owners and Pilots Association, denies any bureaucratic obfuscation on the part of the FAA, but he does acknowledge that the situation can appear that way. "Some government employees go into a protective crouch—and I understand why—when somebody comes around from a consumer organization because they are so off the wall."

"One of the major accomplishments that we've had was bringing the FAA down a notch or two, making them more approachable and more amenable to listening to ideas from the outside," Witkowski says. In 1984 he noticed that the *Washington Post* and the *New York Times* were giving conflicting figures about midair near-collisions. ACAP filed a request under the Freedom of Information Act for reports from the FAA of midair near-collisions and operational errors. He discovered that the FAA had understated the number of near-collisions in 1983 and 1984 by at least 63, based on pilots' reports from three of the FAA's nine regions. Furthermore, some reports listed as operational errors could also qualify as near-collisions. ACAP called ABC News, which confronted the FAA with the information. The agency acknowledged that some reports from FAA regions had not been forwarded to its Washington headquarters but added that the discrepancy had already been noted and corrected.

"The consumer activists said, 'Aha!

Sometimes ACAP works behind the scenes; sometimes it clamors for attention. "The trick," says Con Hitchcock, "is knowing which time is which."

Because there were five or 10 of these things that occurred, the FAA is hiding hundreds of these things from us," says Engen. "They were trying to blow it into something that was just totally out of context with what was reality. I think frequently when aviation consumer organizations have commented on air traffic procedures, they are out in a field that is really better dealt with by ALPA [Air Line Pilots Association] and ATA [Air Transport Association].... I just don't think that they have the expertise necessary to make a valuable contribution for the safe separation of airplanes."

The debate over deregulation and its assorted aftereffects also continues to occupy ACAP. The group acknowledges that deregulation has created more competition, as Congress intended. "The problem is that the Reagan administration went on an eight-year snooze and let the airlines buy each other up in a manner that Congress had not anticipated," Hitchcock says. Other unforeseen barriers stymied airline startups, such as frequent flier bonuses, the computerized reservation system, hub domination—all examples of the difficulty of predicting an unregulated market. "They [ACAP] have called attention to the necessity, even in a deregulated industry, for the government actively to be involved in trying to protect consumers," says deregulation architect Alfred Kahn.

Early last year ACAP filed a statement with the Department of Justice opposing the merger of the computerized reservation systems of American and Delta on the grounds that it would create an unfair marketing advantage for the two airlines. "That made some airlines think we were absolutely brilliant in our analysis and some airlines think we were absolutely crazy," says Hitchcock. The justice department rejected the merger proposal.

As with deregulation, not every battle turns out as ACAP had hoped. In 1973, on the day before Thanksgiving—the

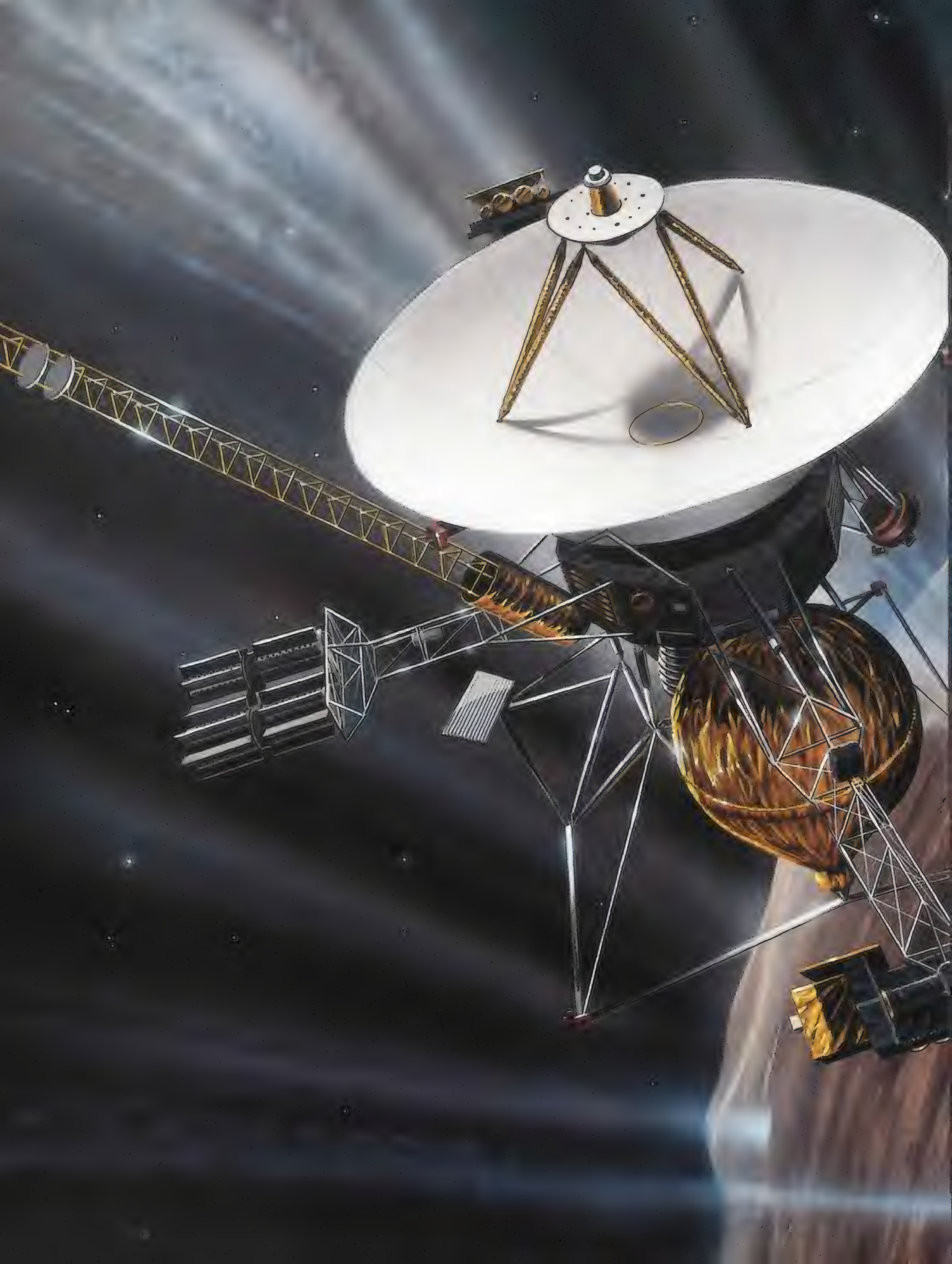
RICHARD T. NOWITZ



worst day of the year for no-shows and airline overbooking—volunteers for the young ACAP assembled at Washington, D.C.'s National Airport to pass out leaflets advising bumped passengers of their rights. After FAA security police stopped the distribution, ACAP got a court injunction based on the First Amendment. Unfortunately, that court action paved the way for every other group to pass out literature at airports.

"It's one of our more dubious achievements, perhaps," Hitchcock says.

Today, a wiser, more mature ACAP practices less guerrilla advocacy. Instead of getting thrown out of meetings, Witkowski and Hitchcock are put on committees. As Hitchcock says, "I think the aviation community is sufficiently closeknit that, at this point in time nearly 20 years later, we're a member of the club—grudgingly so." ➔



A dramatic illustration of a comet's icy surface, characterized by deep, dark crevasses and bright, glowing blue and white ice formations. In the lower-left foreground, a metallic harpoon-like probe with a glowing yellow tip is positioned as if about to strike the surface. A small gas torch with a bright yellow flame is also visible near the probe. The background is a dark, starry space.

To Spear a Comet

Scientists are preparing a harpoon that will capture some fundamental secrets of the solar system.

by Stephen Cole

Illustrations by Paul DiMare

William Boynton stands in the parking lot behind the University of Arizona's football stadium, peering up at a thin white harpoon that dangles over the stadium's edge. As he watches, a figure reaches over the rim with a small gas torch and burns the rope holding the harpoon. The tether parts, and the 80-pound steel spike plummets ten stories, thin wires guiding it to a bull's-eye in a 55-gallon drum of ice.

Boynton is practicing spearing a comet. If all goes according to plan, sometime after the turn of the century this planetary scientist will become a cosmic Captain Ahab, hunting his prey as intently as the fictional whaler stalked Moby Dick.

Comets, celestial oddities once feared as harbingers of destruction, have intrigued man for centuries. Notoriously difficult to study, they often appear without warning, diving toward the sun from every direction. Some travel around the sun every few years, while others pass through the inner solar system just once, never to return.

Scientists believe that comets nor-

On July 20, 2001, with CRAF orbiting eight and a half miles from Comet Kopff, a rocket motor propels an instrument-laden penetrator toward the comet's icy nucleus. Fifteen minutes later impact occurs.

mally reside in the Oort cloud, a distant halo that circles far beyond the planets. As comets approach the sun's heat, they adorn themselves in a blaze of plumage. They grow a thick coat of gas and dust—the coma—and sprout a tail that flows tens of millions of miles out into space. Until recently, this display had always hidden the comet's mysterious nucleus, thought by scientists to be a "dirty snowball" of ice and dust several miles across that formed in the early days of the solar system. Then on March 14, 1986, the European space probe Giotto came within 400 miles of Comet Halley, returning the first close-up, high-resolution photographs of a comet's nucleus. They showed a potato-shaped object covered with a black crust—nearly the darkest surface ever seen in the solar system. This was no fluffy snowball.

Although the flyby provided a flood of data, it left many questions unanswered: What gives Halley its irregular shape? And what is the dark crust made of? Now scientists such as Boynton are working on the most ambitious comet-hunting mission yet: for the first time a comet will be penetrated.

NASA has gotten the green light to build a spacecraft that will fly in formation with a comet and skewer it with Boynton's instrument-laden penetrator.

The Comet Rendezvous Asteroid Flyby mission, slated for launch aboard a Titan IV in 1995, will also fly past an asteroid on its way to a three-year journey with Comet Kopff, a moderately bright comet that orbits the sun every six and a half years. Five years after its launch CRAF will meet up with Kopff near Jupiter's orbit and watch as it brightens, travels around the sun, and slowly fades. The copious data that CRAF radios back to Earth should bring comets in from the cold, providing information on everything from their own origins to possibly even the origins of life on Earth.

Despite nearly two decades of lobbying by U.S. comet scientists, NASA has never built a spacecraft to rendezvous with a comet. "Comets come by like streetcars. If you miss one, well, you can just wait awhile and another one will come along," says CRAF scientist Glenn Carle, head of solar system exploration at NASA's Ames Research Center at Moffett Field, California.

But then along came a streetcar named Halley. Although the Soviet Union, Japan, and the European Space Agency all flew spacecraft to the famous comet when it visited the inner solar system in 1986, NASA ended up staying home. Starting in the late 1970s a succession of U.S. Halley rendezvous mis-

sions had been proposed to NASA, but none of them ever got off the ground. A joint mission between the United States and the European Space Agency was in the works, but NASA backed out at the last minute.

"There always seemed to be other things to do," recalls CRAF project scientist Marcia Neugebauer of the Jet Propulsion Laboratory in Pasadena, California, who served on the seemingly interminable series of Halley study groups. The Europeans decided to go it alone, and with barely enough time to put a mission together, launched Giotto.

Although Halley was the logical target for a comet mission—it was by far the brightest, most active comet with a well-established orbit—it had one nearly fatal flaw: it flies backward. Halley orbits the sun in the opposite direction from all the planets and, consequently, any spacecraft launched from Earth. A probe flying into Halley's dust-filled coma would meet the comet almost head-on at 150,000 mph.

The two Japanese spacecraft, Sakigake (Pioneer) and Suisei (Comet), did not venture closer than 90,000 miles, measuring the effect of the solar wind on the comet and imaging the huge sphere of hydrogen flowing from Halley. The Soviet Vega 1 and 2 craft carried cameras and dust and gas analyzers to

UNIVERSITY OF ARIZONA, LUNAR AND PLANETARY LAB (3)





The nature of comets makes dry ice and steel props the tools of William Boynton's unusual trade.

A full-size penetrator model hurtles through the air after being fired from a rocket sled at Sandia National Laboratories in New Mexico. The spray of ice indicates a successful impact.



within 5,000 miles of the nucleus, pinning down its position so that Giotto could carefully move in with its camera. Even so, seconds before its closest approach Giotto was struck by dust, which damaged the spacecraft and temporarily knocked out its radio link with Earth.

Not only will CRAF get closer to Comet Kopff than Giotto did to Halley, the encounter will take place under more hospitable circumstances. CRAF's trajectory will put it in an orbit that precisely matches the comet's, allowing the spacecraft to fly with the comet instead of just crossing its path. Kopff is also an active short-period comet, meaning that once it is heated by the sun, it will produce plenty of gas and dust for the spacecraft's instruments to sample. CRAF has 14, including cameras, spectrometers, an electron microscope, and several devices that will collect and analyze the gas, dust, and ice that stream from the comet.

Boynton's rocket-propelled penetrator will be the only instrument to conduct experiments inside Kopff. In the early stages of mission planning, when scientists were deciding what they should bring along, the penetrator was considered as a tool to detect gamma rays below the surface, which would indicate the elements that make up the comet. Not surprisingly, Boynton,

a chemist who has spent two decades deciphering the chemical complexities of meteorites and lunar rocks, felt that just identifying a comet's elements wasn't enough. He wanted to know the exact molecular composition. "The comet could be made up entirely of amino acids and we'd only know that it has so much carbon, so much oxygen," he says. "I started to wonder what else you could bring along with you if you're going in that close."

When NASA called for proposals to build the CRAF instruments in 1985, Boynton submitted a penetrator design that included a miniature laboratory with two small ovens, which could determine the physical state of the comet ice sample—a clue to the temperature at which the ice formed—as well as its molecular composition.

The trick, however, was getting the ice into the penetrator. "I knew other people had worked unsuccessfully on bringing samples inside a penetrator," says Boynton. "I had this new scheme, a rectangular spout on the penetrator shaft that would scrape off a sample of ice as the penetrator pierces the comet. It seemed to work on paper, but I felt the review panel wouldn't buy it unless they had some proof that it worked."

So began Boynton's career in ice and steel. On the first drop from the football stadium the scaled-down 80-pound spike shot straight through the crushed ice and pierced the bottom of the steel drum. The next time around a layer of phone books placed under the barrel to absorb the impact caused the penetrator to bounce back out. For the third drop Boynton filled the barrel with blocks of solid ice, which slowed the spike down but still allowed a successful penetration. In all three drops, the inch-wide spout neatly scraped off a small quantity of ice and forced it into a U-shaped track inside the shaft. Boynton, proof in hand, won the contract to build the penetrator.

Two years later, to determine how the penetrator would handle a non-perpendicular impact, Boynton conducted tests with a full-size, five-foot-long penetrator fired from a rocket sled at Sandia National Laboratories in Albuquerque, New Mexico. After speeding down a 100-foot-long steel beam at 90 mph, the funnel-shaped prototype



flew into the air and slammed into solid ice at various angles. The penetrator buried itself firmly each time.

But comets are probably not solid ice, so Boynton is preparing another round of rocket sled tests that will use more comet-like ice formulations. He is testing the formulations with an "ice cannon" he built in the basement of the university's space sciences laboratory.

Outside the lab's machine shop, the vertical cannon stands ready to fire a scaled-down version of the penetrator. The cannon's barrel—a five-foot length of three-and-a-half-inch steel pipe connected to a compressed-air tank—is welded to a rectangular frame that stands seven feet tall.

Wearing asbestos gloves for protection, Boynton takes a bucket of steamy dry ice from a freezer and places it on the concrete floor below the mouth of the cannon. He flicks a cord that fires the penetrator. With a sharp bang and a small fusillade of ice chunks, the penetrator buries itself six inches deep.

While Boynton is busy piercing comet stand-ins, CRAF's real target, Comet Kopff, has just wrapped up another trip through the inner solar system after making its closest approach to the sun in January. After 13 observed trips around the sun, Kopff's orbit is pretty well nailed down, but further fine-tuning is still necessary.

When NASA wants to know about comet orbits, it asks Don Yeomans of JPL's solar system dynamics group. From his small cubicle in the sprawling navigation systems building, Yeomans uses a desktop computer to keep track of thousands of asteroids and over a hundred comets.

His work is comet science in the classic tradition that dates back to Edmond

Anatomy of a penetrator: The comet ice sample is analyzed by a gamma ray detector and melted in two small ovens that lie just above the tip. Helium gas stored in a central tank sweeps the comet gas out of the ovens and up into a gas analyzer, which determines the comet's molecular composition. Batteries and electronics nestled below the nozzle will radio data back to CRAF for a full week.

GEOFF CHESTER



The Halley flybys provided the first close-up images of a comet nucleus but left many questions unanswered.

Halley, the man who proved that comets, like planets, travel in mathematically predictable orbits. A comet's orbit is defined by six numbers that precisely describe its elliptical shape and size, its location in the solar system, and the precise time that the comet is closest to the sun. By running these orbital elements through a complex series of equations on his computer, Yeomans produces an ephemeris—a table of the comet's future daily positions.

His database contains information from hundreds of sightings of Comet Kopff dating back to its discovery in 1906; the most recent sightings were made by a Japanese observer in March 1989 before the comet disappeared behind the sun. Despite a long history of observations, Yeomans is worried about Kopff's predictability. "Halley was a very constant, well-behaved comet," he says. "But Kopff is a little squirrely."

The problem is that comets, unlike other objects in the solar system, have their own propulsion systems. As com-

ets near the sun's heat, their orbits can be altered by jets of gas and dust that act like control thrusters. These non-gravitational forces can slow a comet down or speed it up. "For a massive comet like Halley, the effects of these non-gravs is constant over a long time period," says Yeomans. "But a smaller comet like Kopff is easier to push around."

The only way Yeomans can improve his predictions for Kopff is to collect more observations. Unfortunately, Kopff is poorly placed for viewing from Earth on its current trip around the sun. "I've begged, pleaded, and twisted arms to get data on Kopff," says Yeomans, flipping through copies of letters and ephemerides he has sent to professional and amateur astronomers around the world, encouraging them to get out and observe.

Yeomans runs the Kopff observations through another computer program, one that includes the non-gravitational force model, comparing Kopff's actual positions with those predicted by its orbital elements. Ten minutes later he has the numbers that tell him how far reality is from prediction. He then updates the orbital elements and the master sched-



Marcia Neugebauer worked on many comet rendezvous proposals but never got a green light until CRAF.

ule of comet and asteroid positions that CRAF mission planners rely on to direct their spacecraft. "We will get them to the end of the driveway, but the onboard camera will have to find the house," says Yeomans.

CRAF will make its way to Kopff's front door one step at a time. On August 14, 2000, after the camera has sighted the comet, the spacecraft will fire its engine and shift its trajectory to match Kopff's orbit. Over the next several months the spacecraft will close in on the comet and eventually orbit it at a distance of 40 miles. During this phase, Yeomans—in his other role as leader of the radio science team—will get a fix on Kopff's mass, a critical factor in navigating around the comet, as well as an invaluable piece of scientific data that will let him determine Kopff's density. By March 2001 CRAF will orbit just eight

miles above Kopff, and Yeomans will calculate the gravitational field.

CRAF will then pull back a little to search for a good place to send Boynton's penetrator. "We'll be looking for a fairly flat site," says JPL's Marcia Neugebauer. "We don't want to send it down into the side of a canyon." Finally, on July 20, a rocket motor will ignite and propel the penetrator toward Comet Kopff.

After the Halley flybys, comets entered mainstream planetary science in a big way, attracting scientists from other disciplines. "Comets aren't thought of in the same way they once were," Yeomans says. "One of the emerging themes now within the cometary community is the role comets played in the early Earth. Did they help supply the organic molecules that were the building blocks of life?"

"The standard theory has been that the rest of the solar system was superfluous to the origin of life on Earth—Earth was complete of and by itself,"

says Chris McKay, a CRAF mission interdisciplinary scientist at Ames Research Center whose interest in comets stems from his fascination with the question of life's origins. "But if comets did in fact bring the seed of organic material to Earth, the rest of the solar system is not only relevant, it is seminal to life on Earth."

The Halley data has done a lot to foster this notion. Detectors on board Giotto and the Vegas recorded a surprising number of dust strikes and determined that the material contained a large amount of organic molecules.

"Halley showed that comets are just dripping with organics," exclaims McKay. The discovery has led researchers to suggest ways that comets could have brought their payload to Earth. One scenario proposes that a comet's organic molecules could survive a collision with Earth. McKay, however, assumes that the organic molecules of an impacting comet would disintegrate, and he wants to know if the heat of impact would be intense enough to reform them.

McKay recently tested this hypothesis in the lab. He set up a variation on an experiment conducted by Harold Urey and Stanley Miller at the University of Chicago in 1953, which showed how lightning strikes could convert naturally occurring elements in Earth's atmosphere into organic molecules. McKay concocted a mixture of gases in a glass flask that approximated the elements found in Halley. With a high-energy laser beam standing in for the heat of impact, McKay repeatedly zapped the mixture until a dark yellow residue coated the flask. When he tested the substance, he found that it was chock-full of organics.

It's the big questions—How did the solar system form? How did life on Earth get started?—that motivate people like Bill Boynton to spend nine years building a one-of-a-kind instrument and wait another six years for it to reach its target. "On a project like the penetrator you spend a lot of your time on engineering details," says Boynton. "You hope that someday you'll get the time to sit back with your feet up on the desk and think about the big picture."

"Right now I'm betting an awful lot that a week's worth of data in the year 2001 is going to be worth all this." ➔



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The Great Alaskan Fishlift

When it's June in Bristol Bay, men gotta fish and fish gotta fly.

Photographs by Jordan Coonrad

by Elaine de Man

The summer salmon season means long hours at airfields across Alaska. King Salmon, with its hauler-friendly 8,500-foot airstrip, stays especially busy (left); at the village of Kenai, fuel tanker-cum-fish hauler "Murph" prepares for a twilight takeoff (below).

It's midnight in Alaska, and the sun is just now beginning to set. A small group of men are huddled near the end of the ramp at Kenai Airport, where five DC-6s and two C-97 Stratocruisers are parked. One of the Stratocruisers has an engine cowl off, and mechanics are working to get the huge cargo plane ready to go. Burnie Hall, looking frustrated, takes off his baseball cap, rubs one hand across his forehead, and repositions his cap as he marches across the tarmac. "Murph," the airplane under repair, should have been in the air by now.

Steve Foss, Hall's partner, is sitting in the pilot's seat with the window open watching the mechanics. Last night Hall and Foss' other C-97, Gertie, was grounded with faulty landing gear. "It affects everything when a plane goes down," says Hall, co-owner of the Stratolift air





Each boat working Bristol Bay is assigned to one of five fishing districts (left). During June, law enforcement officers flying Piper Cubs keep watch over the bay to ensure that boats don't stray out of their districts.

The beach at Egegik is firm enough to support a ponderous C-119 Flying Boxcar, but ebb tide leaves nasty ruts in the sand that can trip up taxiing aircraft.





At the tiny village of Tyonek, fishermen truck salmon up from the shores of nearby Cook Inlet to the log cabin air terminal. There it is loaded onto airplanes bound for Anchorage.

Don Pascoe (in red cap) helps load "totes"—one-ton containers of fish—into a DC-6. Pascoe wasn't thrilled by the smell of fish, but since time is money, he had no problem spending 180 hours in the company of salmon during last year's season.



cargo service. Waiting for Murph 230 miles away—across Cook Inlet, beyond volcanic Augustine Island, on the other side of Katmai National Park—is a 48,000-pound load of salmon, just hauled in from the waters of Bristol Bay.

Each June, the bay, a shallow, muddy lobe of the Bering Sea, is transformed into the richest red salmon fishery in the world. An average of 30 million salmon—mostly reds, or "sockeyes"—thrash their way through the bay toward the winding streams and rivers that are their spawning grounds. Government biologists stationed along the river banks monitor the deluge, and once they are satisfied that enough fish have made it upstream to ensure plentiful harvests in the years to come, they give the go-ahead to the bay's 1,800 fishing boats and the 1,000-plus fishermen who work the shore with nets. Within minutes the water is boiling with fish struggling to free themselves from the mesh.

The season's real challenge comes after the fish are caught. No roads lead to Bristol Bay, so the only way to transport the fish to canneries and processing plants and to the airport at Anchorage is by ship or by airplane. Hall and Foss' Stratolift is just one of the air cargo operations that in the last decade have joined in the effort to get the fish from the bay to the market in as little time as possible.

It's a grueling business. Shippers must receive and process the salmon within two to three days of harvest or it will start to spoil. At the peak of the fishlift airplanes are loaded and unloaded 24 hours a day. Ramp workers keep going as long as they can, catching a



At the Inlet Salmon processing plant in Kenai, workers clean, freeze, and pack up salmon for shipment to Japan (top).

Unlike salmon, halibut are fished in sporadic one- or two-day periods throughout the year, so halibut-hauling can be even more frantic than salmon-shipping.



catnap or a bite to eat during the odd lull. Flies are constantly buzzing around the fish, mosquitos swarm around the haulers, and little insects called white socks nibble away at exposed arms and legs, leaving small rose-colored spots that in a couple of days turn into festering lumps.

Still, plenty of regional airlines and cargo services, as well as independent pilots, are willing to put up with these conditions for a piece of the season's action. The going rate for flying salmon ranges from about 15 to 80 cents a pound, depending on the distance. In 22 hours, one pilot flying a Cessna 180 made over \$3,000—close to \$140 an hour.

And the market is growing. In the past decade Japanese and American tastes have been turning toward unprocessed fish. Ten years ago the United States produced only 176,000 pounds of fresh and frozen salmon fillets and steaks; last year that figure was 8,915,000 pounds—a 50-fold increase.

The C-119 scoots about 50 feet over a low, rolling moraine. There's a Disneyland-like quality to the flight as the Flying Boxcar passes over lakes speckled with water lilies and dotted with swans. Caribou grazing on the golden tundra lift their heads to watch the cargo plane rumble by.

Five times a day, weather permitting, pilot Roger Bartels makes the trip from King Salmon, on the shores of the Naknek River, to Egegik, a tiny bayside village 45 miles to the southwest. Today a 20,000-pound haul of salmon is to be shipped fresh in 10 "totes"—aluminum or plastic containers. The fish have been ready since the previous afternoon, but yesterday the tide was in and the landing strip, such as it is, was under water. Later in the evening, when the tide was out, the fog rolled in.

When the Boxcar reaches Bristol Bay, Bartels dips its nose over a sandy ridge and makes a steep turn to fly along the shore. He flies over a few airplanes parked on the beach and a scattering of aircraft wreckage. He zooms past a windsock fluttering from a pole. Up ahead is a jumble of buildings that make up the Egegik cannery, and along the beach people are racing toward it on all-terrain vehicles towing little trailers full of fish. Everyone ignores the low-flying airplane. "Sometimes you've got to fly along real low," says Bartels, "or these people don't think you're serious about landing here." He swings out over the bay, flies back along the now-deserted beach, and lands.

During the explosive salmon season, Piper

Delivering salmon is a little like delivering babies—a 4 a.m. arrival is nothing unusual (above). No one knows that better than Lynn Shawback (right), who has loaded and unloaded over a million pounds of salmon in a single day.



Cubs, DC-3s, and even lumbering DC-6s all vie for position on the beach, which is, as the pilots will tell you, a “good, firm one.” However, when the tide goes out it can leave ruts up to a foot and a half deep in the sand. One of these contributed to the destruction of a DC-6 taking off from the Egegik beach in 1985.

According to the National Transportation Safety Board report, it was 1:15 in the morning, still twilight in Alaska, when Captain Stanley Zimmerman started up the engines on a Ball Brothers DC-6 and headed down the beach on his takeoff run, loaded with about 30,000 pounds of fish and ice bound for Kodiak. The airplane accelerated along the shore, then hit a trough in the sand that bounced it into the air about six feet. Zimmerman lost directional control, and the aircraft swerved into the steep bank that runs





Fishing in Bristol Bay is a brief and frenzied business, so the camps that have sprung up along the shores are not elaborate.

along the beach. The left wing rode up over the bank and the fuselage broke in two places, with the front section rolling off to the right. When the airplane came to an abrupt stop, the totes flew forward and broke through the bulkhead and into the flight compartment, spilling fish into the cockpit. The plane burst into flames.

A strong wind blowing down off the bank kept the flames away from the cockpit while rescuers freed the copilot, who was trapped in the wreckage. Though all three members of the crew managed to escape, the airplane and its cargo burned for seven hours.

Getting the fish safely airborne isn't the only worry. At the bush village of King Salmon,

which boasts an 8,500-foot runway, Scotty Bushman, ramp supervisor for Far West Fisheries, has just discovered that one of his DC-6s has taken off for Anchorage with 14 tons of someone else's fish. And shipping coordinator Lynn Shawback is keeping his eye on a couple of unclaimed totes of once-fresh salmon that have been moved around in circles for a couple of days.

Another worry is that the totes will leak. Smell notwithstanding, fish slime grows bacteria that secrete acids capable of eating through aluminum and shorting the wiring. Several years ago, one regional airline found well over \$100,000 in corrosion damage during a major check of a C-130 that had put



Bringing in the catch in a Cessna 180, Bob Kempel has become well versed in the vicissitudes of Alaskan bush-flying; last year he landed at Tyonek only to encounter a mama bear and two cubs settled in on the runway.

in five years hauling fish. According to MarkAir vice president K. Gene Zerkel, a fish spill can ground an airplane for half a day and cost \$20,000 in lost revenue alone. To plug leaking totes, Shawback uses o.b. brand tampons; pilots also routinely keep them handy.

By the end of the haul, the airplanes smell abominable. Even so, Jerry Ball, president of Northern Pacific Transport, doesn't hesitate to convert his fleet to fish haulers during the summer season. "Anytime the planes are making revenue," he says, "you don't care what the load smells like." Don Pascoe, who flies DC-6s for Northern Pacific, agrees. Though Pascoe isn't crazy about the smell of fish, the hourly employee enjoys the ample opportunities to rack up flying time. "I'd love to go back up next year," he says, though he'd also like to negotiate a better wage with Northern Pacific. "There are some rough quarters up there," he explains, "and I like a decent bed."

The sometimes-grim conditions can have unique compensations. Standing under the wing of his DC-3 while it is being loaded in the rain, Salair's Gunner Ingle comments, "This is great. I don't have to shave and I don't have to wear a tie."

At last the repairs on Murph are done. The mechanics climb down from its massive wings. Burnie Hall, sitting at the side of the ramp in his camper, hears Steve Foss start up the engines. He opens his eyes.

It's close to one in the morning now. Beyond the serene expanse of Cook Inlet the sun is well along in its descent, dropping behind Redoubt Volcano and bathing the entire Alaska range, as far as you can see, in a salmon-colored glow. ➔



Alaska Airlines can convert a passenger-carrying 737 into a fish-bearing "Salmon-30-Salmon" in under half an hour.



Alan & Cober

Our daring correspondent's jottings
as he travels to the Soviet Union to
witness missile eliminations—and
returns with a unique souvenir.

by Gregg Herken

Illustrations by Alan E. Cober

Kapustin Yar Diary

On December 8, 1987, the United States and the Soviet Union signed the Intermediate-range Nuclear Forces Treaty, which called for the elimination of an entire class of nuclear missiles, including the most accurate and deadly of them, the Soviet SS-20 and the U.S. Pershing II. Last April, in the culmination of a two-year quest by the National Air and Space Museum to acquire an SS-20 for display, Gregg Herken, chairman of the Museum's space history department, was invited by the Soviet government to travel to the base where the missiles are being inspected and eliminated. While traveling, Herken kept a journal of his experiences.

April 18

Sheremetyovo airport, Moscow, 5:50 p.m. I'm met at the airport by a driver; Andrei, the translator; and an official from the NRRC, the Soviets' Nuclear Risk Reduction Center. We form a flying column through Customs—no more than 10 minutes, a new record. On the wild ride into town we get the first evidence of *perestroika*: the driver gets a speeding ticket from a radar-equipped cop. Appeals to our official status—the car has Soviet and American flags on the dash—are unavailing. Says Andrei, "It doesn't matter whether you are minister anymore. It is democracy."

April 19

Ukraine Hotel, Moscow, 9:15 a.m. Revived after a night's sleep, despite what

sounded like Georgian dancers with a bad boom box in the lobby around 3 a.m. Mercifully, their batteries died.

Ukraine Hotel, 7 p.m. Finally meet up with the team from the On-Site Inspection Agency—the U.S. counterpart of the Soviet NRRC—and the head NRRC guy, Colonel Gennadiy Komogortsev. Counting the team's leader, Lieutenant Colonel Dennis Deeny, there are 11 members of "Team Deeny," as it's known. All are wearing the OSIA "uniform"—blue jacket with an American flag and the OSIA emblem, plus a baseball cap with "OSIA" on it.

There is already some confusion among the Soviets about my status in the group. While the members of Team Deeny eat at one table, Komogortsev and I are seated by ourselves at another. Since neither the colonel nor I speak each other's language, Deeny—who knows some Russian—comes over to join us and translate.

Komogortsev is rather slight and seems a man of few words, Russian or English. Since I am not an OSIA inspector, I pay for my own dinner, which comes to five rubles—about 90 cents.

April 20

On an AN-72 bound for Volgograd, 10 a.m. The airplane, a twin-engine jet bushplane originally designed for Arctic exploration, pops up from the runway like a cork. One theory why we're using this aircraft is that it lacks windows. Team members say the Soviets proba-

bly put us on it less because they feared what we might see than because they resented that their inspectors are treated this way in the States.

On the road to Kapustin Yar, 2 p.m. Upon arriving in Volgograd, we are met at the airport by the Soviet officers who will be our escorts while at Kapustin Yar, the missile test center where all SS-20 eliminations take place.

Either to honor us or to minimize our contact with ordinary citizens, the Soviets put us into three green and white mini-vans, which are escorted through the city by civilian police and military jeeps, lights flashing and sirens wailing. Our caravan sends children and babushkas scrambling as we sail through intersections against the lights. I doubt this will do much to improve Soviet-American relations, since the flags on the vans let everybody know who's to blame.

Just an hour outside Volgograd the terrain is completely flat and almost featureless. We stop only once during the three-hour drive. When we get out of the vans the silence is eerie. The only sound is the wind, which apparently blows constantly.

Kapustin Yar suddenly appears out of nowhere, like an oasis in the desert, and we blast through the residential area and factory district in a similar fashion. In this case, though, every intersection is already blocked off with a Soviet army truck and a soldier standing guard. People on the street look up as we whiz by but nobody waves.

The barracks, Kapustin Yar, 6:30 p.m. The members of Team Deeny, our escorts, and I are assigned rooms at the three-story barracks where we will be housed and fed during the missile eliminations. Since Kapustin Yar is a sensitive military base, we are, in effect, under house arrest while here. Although we are allowed in the corridor and the bathroom by ourselves, no American can leave the floor, much less the building, without an escort.

The barracks' briefing room, 7 p.m. In a so-called "pre-briefing"—which, under the terms of the INF treaty, has to occur no more than an hour after the INF inspectors arrive—Colonel Oleg Medvedev, the base commander, welcomes Team Deeny and me to Kapustin Yar. In accordance with the terms of the treaty, Medvedev and Deeny synchronize their watches and announce that this round of inspections and eliminations is now under way.

Almost immediately, however, a mini-crisis erupts over my presence. Komogortsev stands up and gives a little speech that says, in essence, that the Soviet side is very honored to have a special guest from the National Air and Space Museum, but what *is* he doing here?

This appears to be a case of the Soviets keeping secrets from one another and somebody not getting the word. But the Soviets seem satisfied when Deeny explains that while I am not an INF inspector, I am an observer here at the invitation of the Soviet government.

There are a total of twenty-four SS-20s to be inspected by Team Deeny and eliminated. Twenty-two are live missiles—nine were previously deployed and have been moved to Kapustin Yar from their bases, and 13 were never deployed. The two remaining SS-20s are unarmed factory seconds used for training. One of the trainers is the missile bound for the Smithsonian. Its canister, which normally contains the missile until it is to be launched or eliminated, will be made inoperable and put on display in Kiev. The other trainer will be treated the same as a real SS-20—wired with explosives and blown up.

After Medvedev's briefing, Komogortsev announces that lunch—which we missed on the flight from

Moscow—will be served in half an hour, with dinner to follow an hour after that. This is apparently the result of Soviet sensitivity to the fact that the INF treaty says that inspectors will be fed three meals a day. It takes some doing for Deeny to convince the Soviets that the American side will not consider missing lunch a case of non-compliance with the treaty.

After the Soviets have left the brief-



The unmistakable sound of a chainsaw starting up erupts from next door.

ing room, Deeny and a few others stay behind to telephone the American embassy in Moscow to clear up some details, including my status as observer. Since it is hard to imagine having a private conversation at a Soviet missile base, there is much pointing at the ceiling, silent lip-reading, and passing of notes as we try to decide what to tell the embassy.

Abruptly, the unmistakable sound of a chainsaw starting up erupts just outside the door. Our Soviet escorts, it turns out, are watching the Russian equivalent of *The Texas Chainsaw Massacre* in the TV lounge across the hall. Since the ban on pornographic and violent films was only recently lifted—more evidence of *glasnost*—the movie is a big hit. The chainsaw and ensuing screams are deafening. The idea that the Soviets are eavesdropping now seems ludicrous. We ask our interpreter if there is a Russian phrase for "Keep it down!"

April 21

Missile pit 5A, 6:30 a.m. It is still dark

when we are driven out to inspect the SS-20s. We travel about 13 miles to a T-intersection. To the left, a paved road leads to the Polygon, a 30-foot-high observation tower from which the team and I will observe the missiles being blown up. To the right is a dirt road that goes out to the shallow pits containing the missiles.

The ground around the missile pits is covered with tiny metal fragments that used to be SS-20s. Nearby are deep craters where the missiles sat when they were blown up; they give the barren ground the look of a moonscape.

The escorts, in green fatigues, climb inside or stand closely around the canisters while the inspectors, using tape measures and fiberglass rods, confirm that the dimensions of the missile and canister are correct for an SS-20. (According to the official INF chart, the length of an SS-20 is exactly 14.657 meters—a little over 48 feet—excluding its top.) Since the missiles never leave the canister, the inspectors measure the length of the canister and the distance from the canister end to the missile, subtracting the difference to get the length of the missile.

Next to the aft end of each canister, looking like a giant green oil barrel, is the Launch Assist Device. In a launch, the LAD would pop the missile far enough out of the canister for the first stage to be ignited. On the other end of the missile, the reentry vehicles and instrumentation compartment have been removed from the top of the second stage. They are at the Polygon, where they will be crushed by a powerful hydraulic press. (The warheads have also been removed and may, as allowed by the treaty, be used in other missiles.) The green missile inside the canister looks appropriately sinister, like a large animal in a dark cave.

The inspection of the missiles in pit 5A takes about 15 minutes. The measurements check out; the team is convinced that the things in the canisters are both SS-20s.

The team has also put tamper-proof seals on each canister. These look like metallic versions of the tags that K-Mart uses to discourage price switching. They will be checked by an inspector before the missiles are blown up to ensure that the Soviets haven't

switched missiles on us. It seems to me that this would be magic beyond the talents of David Copperfield. You couldn't hide a rabbit in this terrain, much less an eight-ton missile.

The Polygon, 11:20 a.m. The Polygon has Soviet and American flags flying and a big sign featuring a missile broken in half and the Russian words for "Disarmament Through Dialogue." Here we're finally going to see the missile destined for the Smithsonian. On the other end of the tarmac are four big crates with "National Aerospace Museum" stenciled on the side. In front of them is our missile.

The OSIA team inspects its canister first—the one going to Kiev. Since the Soviets want to put it on display in time for the Victory Day celebration on May 9, they are eager to get it out of here. Two sets of 15 half-inch holes have been drilled on opposite sides of the canister. The Soviets give Deeny a long half-inch-diameter metal rod to poke through the holes to see for himself that the canister is empty. Deeny sticks the rod in the launcher up to the hilt while another inspector confirms that it comes through the other side. The image of slaying a dragon comes to mind, though in his windbreaker and baseball cap Deeny seems an unlikely Saint George.

Satisfied that the launch tube is dead, we move on to the missile. The trainer is in four pieces—first stage, second stage, post-boost vehicle, and reentry vehicles. Deeny and the team put seals on the first and second stages. Because this is a trainer and has no rocket nozzle and no propellant, the missile is considered eliminated.

The compound, 1 p.m. Some of the escorts are watching a poor VCR copy of *Robocop*. We learn from Komogortsev that the wind is blowing in the wrong direction—toward the Polygon—and hence the blowing up of SS-20s has been delayed. It turns out that the Soviets are not worried so much that the possibly toxic debris from the missiles will rain down on the inspectors as that it will fall on the town of Kapustin Yar and the Volga River, located much farther beyond. Their concern is apparently the result of the Soviet Union's burgeoning environmental movement.

Some of the base's neighbors have been complaining that the SS-20 eliminations are scaring cattle and further polluting the river.

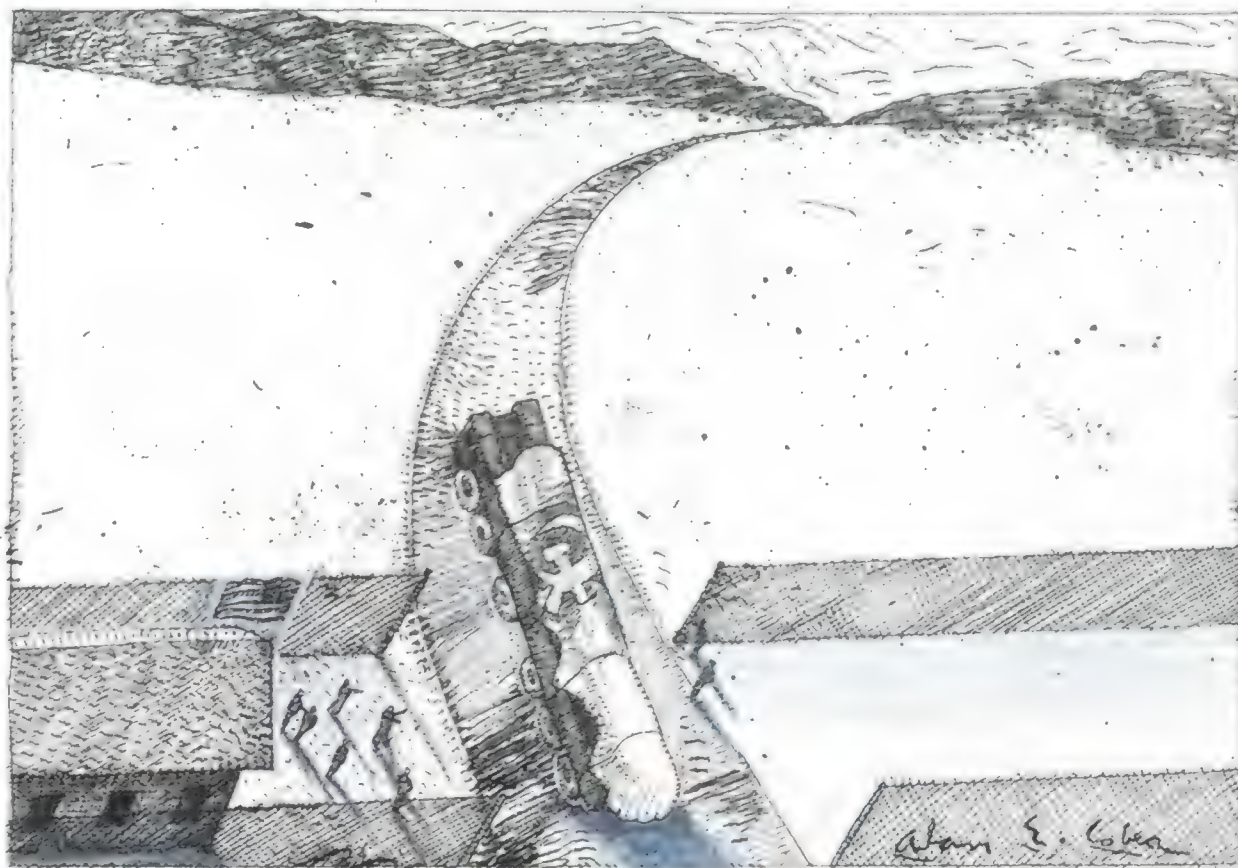
April 22

The compound, 9 a.m. A beautiful morning. During the drive to the Polygon we see, off in the distance, wild ponies said to be left over from the days of Genghis Khan. Last night one of the escorts told us that the last Tartar chieftain is said to have buried a pony made of solid gold around here someplace. The escort added that a number of people who have tried to find it with metal detectors have been blown up by land mines left over from World War II.

The observation tower at the Polygon, 11 a.m. We are still holding because of the wind direction. The American and Soviet flags next to the tower are pointing directly toward us. This is a concern because of what happened in a previous elimination at Kapustin Yar. Not paying sufficient attention to the weather and underestimating the force of the explosion, they put three missiles together and set them all off. Because of a temperature inversion that day, the shock wave blew the windows out of the tower. Apparently, a few inspectors almost followed. Since then, the Soviets blow up only two missiles at a time, and pay more attention to wind conditions.

The observation tower, 12:30 p.m. Komogortsev announces that, because of the wind, the shoot is off until tomorrow morning at ten. However, since today is Earth Day, the colonel says that it has been decided that we and our Soviet escorts will plant a few trees before we head back to the compound for lunch. A few minutes later, a battered fire truck pulls up in front of the tower with five anemic-looking saplings. As the honored "Smithsonian observer," I am asked to dig one of the five holes. The ground, I find, is like stone. Deeny, next to me, is also having a difficult time of it, as are the three other inspectors honored with this task. With the soldiers standing around watching us dig, we look like a chain gang, or prisoners digging our own graves.

After we struggle with the shovels for a few minutes, Komogortsev orders the soldiers to come to our rescue. The trees are put in the holes, water is brought from the fire truck, and pictures are taken. The real purpose of the tree planting seems to be providing a photo opportunity and a symbol of Soviet-American cooperation, but I'm doubtful that the saplings will live to see another Earth Day. There is hardly a tree visible on the horizon, and it is hard to imagine even an oak standing against this constant wind. Next to our saplings, moreover, are nine dead twigs sticking in the ground—the remnants of previ-



ous tree planting ceremonies? But Komogortsev deserves credit for trying—he must feel like the social director on a cruise ship that has run aground.

My room at the barracks, 9 p.m. The joke at lunch today was that I am likely to become the permanent curator of rocketry at Kapustin Yar. Something of a siege mentality is beginning to set in here. But the morale of the inspectors remains high: many, I suspect, have spent their careers in the care and feeding of weapons like these, and they are delighted by the prospect of blowing them up. As we filed out of the barracks on our way to dinner, one of the inspectors put his hand on the shoulder of the person in front of him, hung his head down, and began chanting “The Volga Boatman’s Song.” We all laughed, but this is a bit like being in prison, even with plenty of food and somewhat deluxe accommodations.

April 23

The compound, 9 a.m. Since the flags outside the barracks were hanging loosely this morning, everyone at breakfast was hopeful that today would be the day. They even moved breakfast up to 8:15 so we could get to the Polygon early. By the time we left the mess hall, however, the flags were once again waving and pointing in exactly the wrong direction. Komogortsev joked that there was obviously a sinner among us to bring such bad luck.

The Polygon, 2:15 p.m. After a frustrating morning of watching, testing, and talking about the winds, we get a 15-minute warning of a missile shoot. No one is optimistic—we got one this morning too, and nothing happened.

2:30 p.m. Although it seems like nearly a half-hour since we heard the last 15-minute warning, another warning has just sounded. Everyone feels that we might shoot after all.

2:44 p.m. One-minute warning. Tension builds in the crowd, as Howard Cosell would say.

2:45 p.m. Over the loudspeaker, an announcer counts down in Russian: Ten,

nine, eight, seven, six, five, four, three, two, one—*ogon!* There is absolute silence as a bright red fireball erupts more than three miles away. Sailing up through the fireball are brilliantly burning pieces of rocket propellant, which look like sparklers as they slowly arch down, hit the ground, and go out. Involuntarily, we all make an *ooooohh* sound. No one says a word until the shock wave hits, almost 20 seconds later. Even



The ground around the missile pits is covered with tiny metal fragments that used to be SS-20s.

though I’ve braced myself, it is surprisingly strong. And loud. There is a little nervous laugh from the neophytes—me included—after the shock passes. No blown-out windows this time. Deeny says that when it is foggy you can actually see the shock wave moving toward you through the fog.

At first the smoke and dust from the explosion go straight up, but at a couple of thousand feet it suddenly shifts and starts to head for us. A sense of apprehension grows in the crowd as someone says that the enormous dark gray cloud—which is made up mostly of dirt and the chemicals in the propellant—is thought to be toxic.

3:00 p.m. The bulk of the cloud is now several thousand feet directly above the observation tower. One of the inspectors comments that the smell in the air is just like burning newspaper. Another compares it to burnt marshmallow. We all make a point of trying to take shallow breaths, but no one wants to leave the

tower. The Soviets have given the 10-minute warning for the second shot.

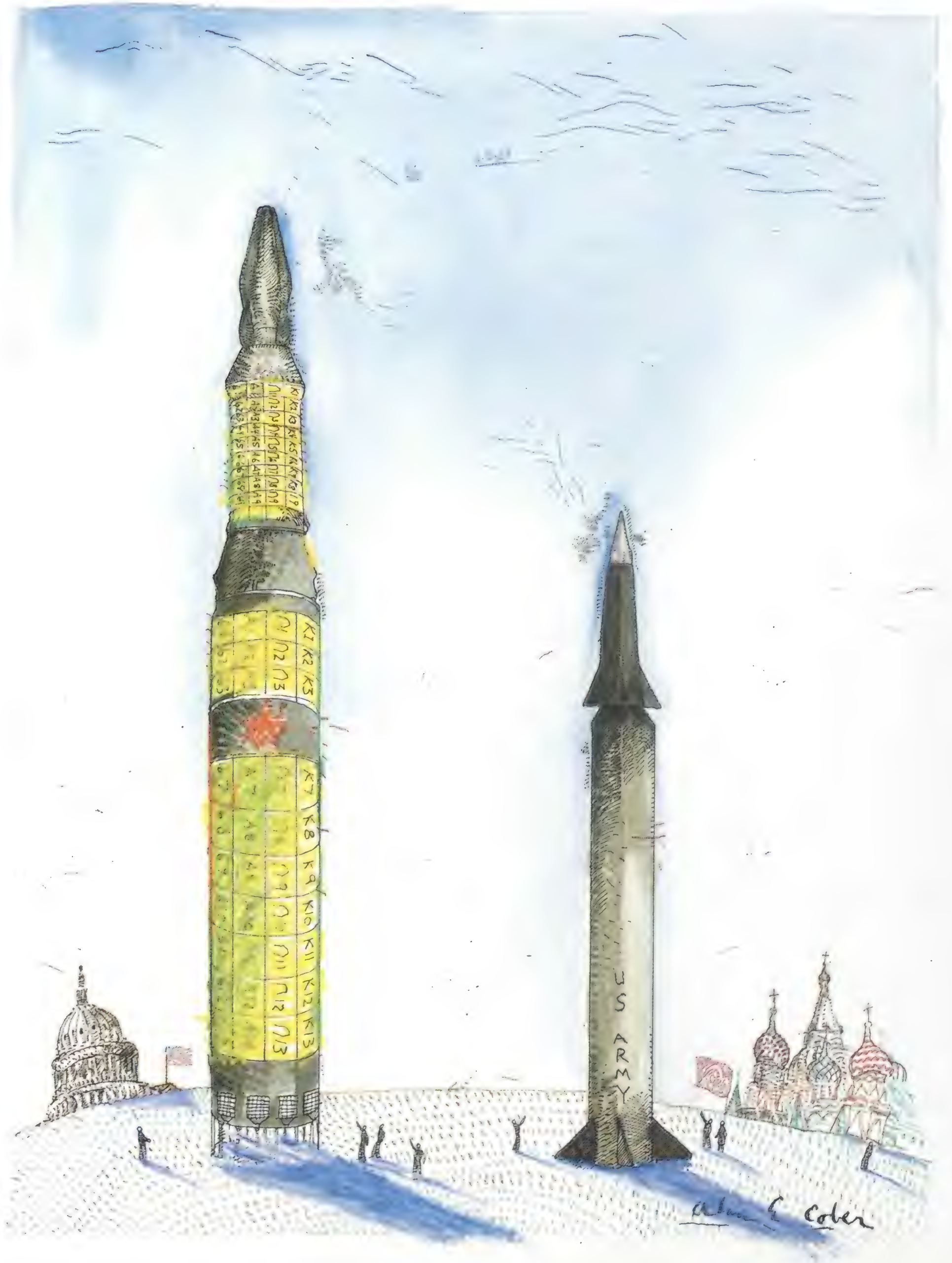
3:05 p.m. We are relieved to find that the smell is burning newspaper. Someone had put a cigarette in a trash can. Nobody seems to know where a fire extinguisher is, so one of the escorts just moves the burning trash can to a corner of the tower and pours a soft drink on the fire. There is no discernible smell from the cloud, which has now passed overhead.

4:35 p.m. The Soviets are now setting the missiles off every 20 minutes. Because this elimination has fallen behind schedule, Komogortsev says he would like to set all the missiles off today, even though we will run later than previous eliminations and it will be twilight by the time of the last shot. Deeny agrees. We will go have dinner, then return to blow up the last six missiles. It stays light until almost nine o’clock now.

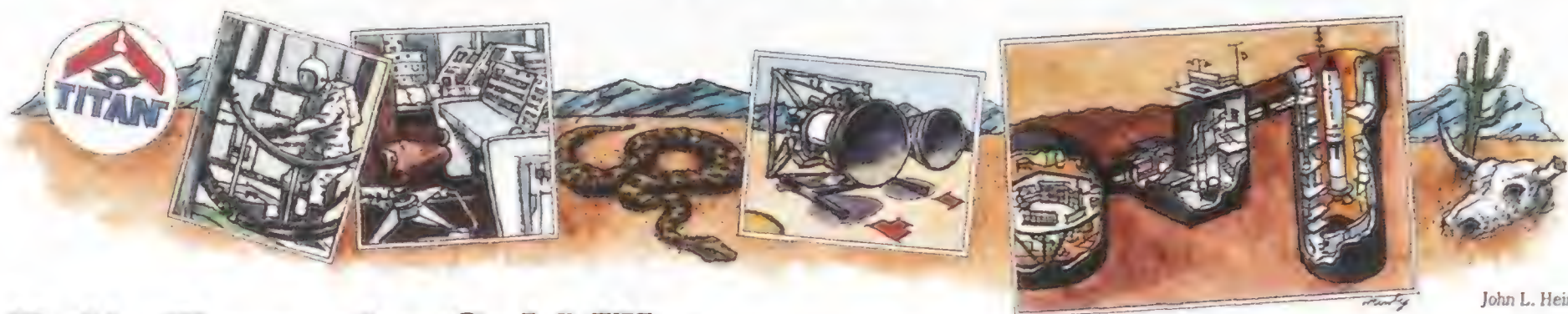
7:40 p.m. The missiles in pit no. 6, the only two left, are about to go. Now that the sun is setting, the fireballs are much more vivid. Rain clouds are beginning to build up on the horizon but the sky is still beautifully clear, with a pink tinge of sunset.

Komogortsev has arranged for the official photographer to take a picture of all of us in front of the fireball when it goes off, so we troop down to stand in front of the tower. But to ensure that no one loses sight of the missiles for even a second, Deeny orders everyone to face the explosion, backs to the camera, at the moment the firing order is given. It is an awfully strange group portrait. After the shot, as the mushroom-shaped cloud is climbing into the sky, we turn and face the cameras head-on.

A ceremony later that night brought an official close to this round of inspection-eliminations. On June 18 the National Air and Space Museum formally accepted the SS-20 into its collection. It stands today in the Museum’s Milestones of Flight gallery beside a U.S. Pershing II missile. Another Pershing II, the second of two donated by the U.S. Army, will soon go on display at the Central Armed Forces Museum in Moscow. —



Collections



John L. Heinly

Relic From the Cold War

Amid the mesquite bushes, cacti, and critters of Arizona's Sonoran Desert sits one of the world's newest museums—and one that is truly unique. There are no echoing halls, no wizened curators, no restored artifacts here. The Titan Missile Museum has just one attraction: a Titan II intercontinental ballistic missile sitting empty and mute in its subterranean den.

From 1963 until 1987, 54 Titans and their nuclear warheads were kept poised for launch at three locations in the United States, their four-person crews waiting for a call that never came. Now the missile sites have been bulldozed and the warheads scrapped, replaced by more efficient machines of war. The missiles themselves—minus warheads—were placed in storage and sometimes brought out to launch payloads into space.

But 25 miles outside of Tucson, dead-south along I-19, in the retirement community of Green Valley, beside a mound of aging copper mine tailings, the world's only operational site/missile museum is welcoming visitors.

The Air Force still owns launch site 571-7, nicknamed Copper Penny for the mineral-rich earth mined nearby, but leases it to the Tucson Air Museum Foundation. Since the museum opened in May 1986, 185,000 people from 167 countries have turned off at Exit 69 onto Duval Mine Road to put on hard hats and descend 35 feet into a hole in the desert. "You'd be surprised how many times Mikhail Gorbachev has gone through there according to the guest book," says volunteer Ben Adams, a retired mining company employee.

Two full-time and three part-time paid employees oversee 110 volunteers. After showing a six-minute video in the reception center, two volunteers lead groups of 20 outside. The more observant visitors will note rattlesnake warning signs by the back porch and the restroom. Later, they'll note another in the coolly attractive recesses of the crew entry area, a useful warning in the days when there was less pedestrian traffic to frighten away the rattlers.

The next stop on the tour is the first-stage engine, which has been detached and

positioned above ground. A few feet away, visitors can peer through huge glass panels that cover half of the mouth of the 146-foot-deep, 55-foot-diameter silo. The 740-ton concrete and steel launch door that was used to seal the silo is now welded half open. Just below the silo's opening is an orange and black nosecone that sits atop a white and silver missile. This particular Titan was never operational. The 10th of more than 140 built by Martin Marietta, it was used at Sheppard Air Force Base in Texas for training. Even so, technicians cut holes in its nosecone and fuel tanks, ensuring that the missile was impotent.

Down a few steps into the first of three underground buildings, the environment changes abruptly. From the clear air and blazing sunlight outside, long stairways lead tourists into artificial light and the smell of hydraulic oil. Then they pass through a series of three-ton blast doors designed to protect the crew from radiation and shock waves in the event of a nuclear attack.

A narrow passageway connects the first underground building to the control center, which has three levels: crew sleeping and eating quarters on top, control center in the middle, air conditioning and other equipment below. This egg-shaped facility is actually a building within a building: the entire structure is suspended within an outer shell from eight huge springs that would soften the shock waves of all but a direct hit by a thermonuclear missile. If necessary, the crew could survive in their concrete and steel fort for 30 days.

Four-person crews—two members of which were always awake in the control center—worked 24-hour shifts in a labyrinth of cables, gauges, switches, monitoring equipment, and cooling fans all designed for one purpose: to launch a single retaliatory shot in defense of the United States. "Sitting there waiting to go . . . like a bullet in a gun," recalls former Titan crewman Pete Morrison, now a museum volunteer. All is quiet now, but former crew members recall how the constant noise from fans and other equipment left them tired beyond the demands of a constant state of alert.

To launch their Titan missile, the crew commander and deputy commander each had to place keys in separate consoles several feet apart, turn them within two seconds of each other, and hold them for five seconds. Some tour guides play a simulation of what a crew would need to hear to fire a missile. "Break, break," squawks the voice, "this is a red-dash-alpha message in two parts."

Visitors most often ask about construction costs, which totaled \$8.3 million per site and \$2.2 million per missile back in the 1960s. Some ask technical questions, and if the tour guides can't answer them, they are referred to the research staff. Other inquiries are easier. At the end of one tour, energetic museum manager Becky Roberts asked if there were any questions and was rewarded with "Yes, where did you get your sunglasses?"

Their hardhats bobbing in single file down a 200-foot passageway, the tourists' final subterranean stop is at the third building, the silo itself. At the silo's second level, where refrigeration equipment kept the rocket fuels cooled, there are windows set in the two-foot-thick silo walls through which visitors can see two mannequins posed as rocket fuel handlers, an odd mixture of natural and artificial light washing over their stiff forms.

Back at ground level, in the bright glare of the Santa Cruz Valley sun, the cool, dim place below seems a world away. "It was so large and made you feel so small," said Betty High, a recent visitor who lives in Tucson. "The main thing I thought of was how wonderful that we don't have to think about using them anymore. That was the best part."

—Bob McCafferty

Titan Missile Museum, PO Box 150, Green Valley, AZ 85622. Tel. (602) 791-2929. Hour-long guided tours every half-hour, 9 a.m. to 4 p.m. Daily, November 1 through April 30; Wednesday through Sunday, May 1 through October 31. Admission: adults \$4, children free. Reservations are recommended. High heel shoes not allowed.

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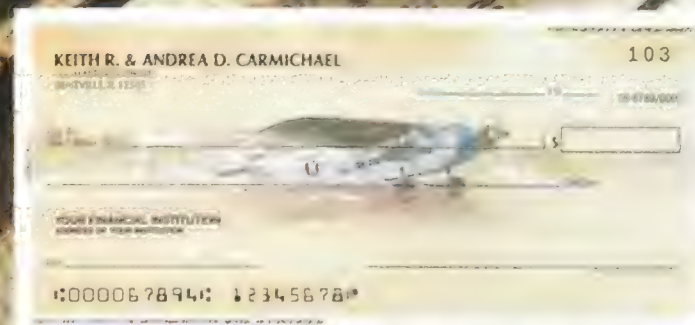
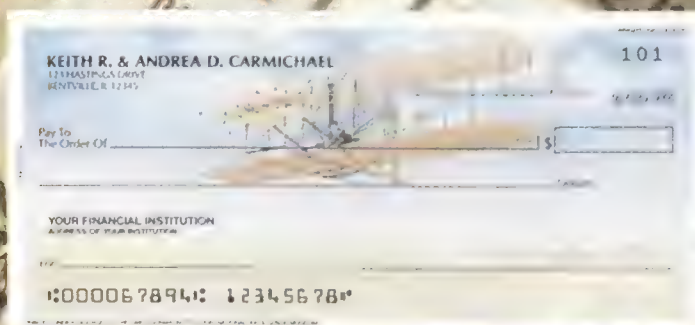
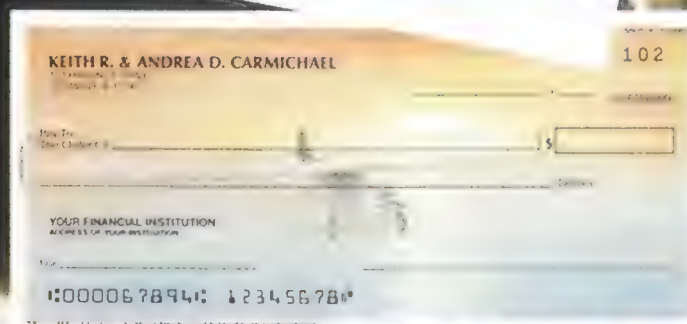
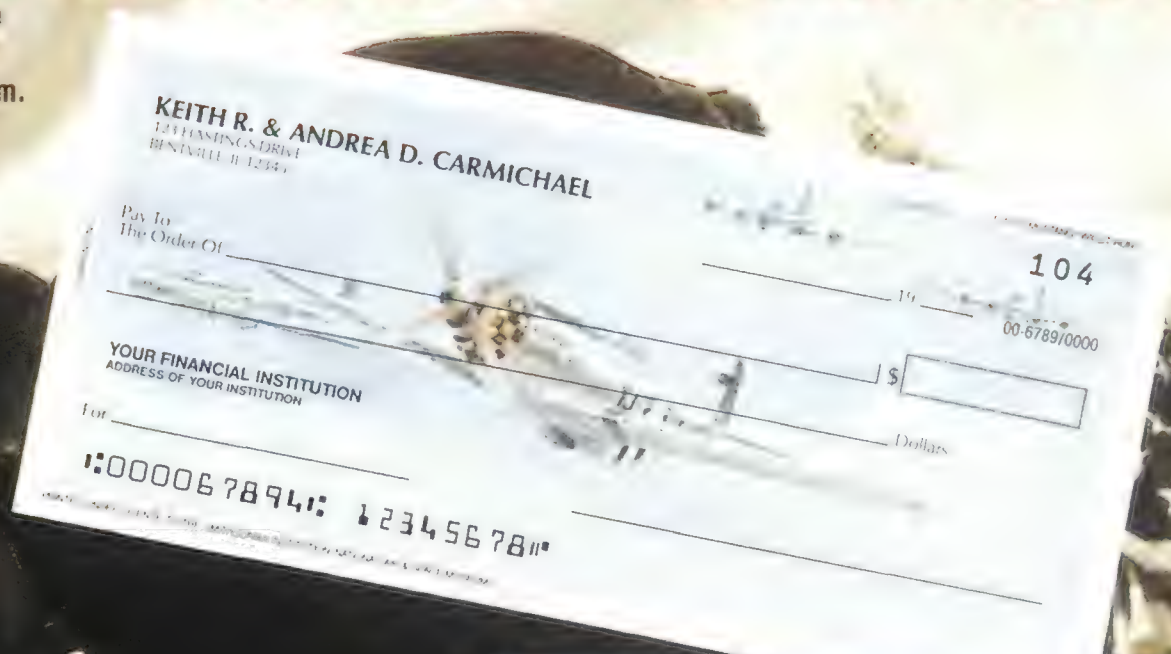
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Shooting the Stealth

James C. Goodall and John Andrews stand alongside a barbed wire fence, training their binoculars on a row of hangars eight miles away. They are about two and a half miles from the main security gate at Tonopah Test Range in the Nevada desert, which is about 34 miles from downtown Tonopah and another 207 miles northwest of Las Vegas. It is the middle of December, and they are just about in the middle of nowhere. From their vantage point Goodall and Andrews can barely make out cars and trucks on the roll in the distance, but they know that when the doors of the cavernous hangars open wide, they will soon see one of the government's best-kept secrets—the F-117A stealth fighter—fly overhead.

Goodall is an amateur photographer whose photos of the F-117 appeared in the trade publication *Aviation Week & Space Technology* months before the aircraft was unveiled to a curious public last spring. Andrews is the plastic kit manager of the Testor Corporation, a leading manufacturer of model airplane kits. He is in Tonopah to refine his drawings for Testor's F-117 model. "We try real hard to get it correct," he says. "It's reputation. It's also integrity." It's also, he adds, a \$175,000 investment in tooling alone. Andrews is quite pleased when one of the mysterious black arrows finally flies overhead. "I think my drawings are finer than they've ever been," he says, peering through his binoculars. Goodall, whose motor-driven camera clicks and whirs as long as the aircraft is in its range, describes the experience as "sexual."

The F-117A has been operational since 1983, but its existence wasn't even acknowledged by the defense department until November 1988, when the Air Force released a single blurred photo. Not until last spring, after nearly a decade of skulking around the southwestern desert at night, did the supersecret stealth fighter go fully public. The official Lockheed photos, clear and crisp, were snatched up by TV networks, newspapers, and magazines everywhere.

But to a handful of aviation enthusiasts, the debut was yesterday's news. Andrews'

JORDAN COONRAD (2)



drawings of the model were off by only three percent in span and one percent in length. And *Aviation Week* had already run a number of pictures taken by amateur photographers stalking the aircraft in the desert.

Some of the first photos the magazine ran were taken in the spring of 1989 by Byron Aughenbaugh, a high school physics teacher from Escondido, California. Last year Aughenbaugh decided to make the 420-mile pilgrimage to the Tonopah test range, the aircraft's home base, during his Easter vacation. "I hadn't seen a single photograph taken by a civilian," he says, "so I'm wondering: Why aren't there any pictures of this plane?"

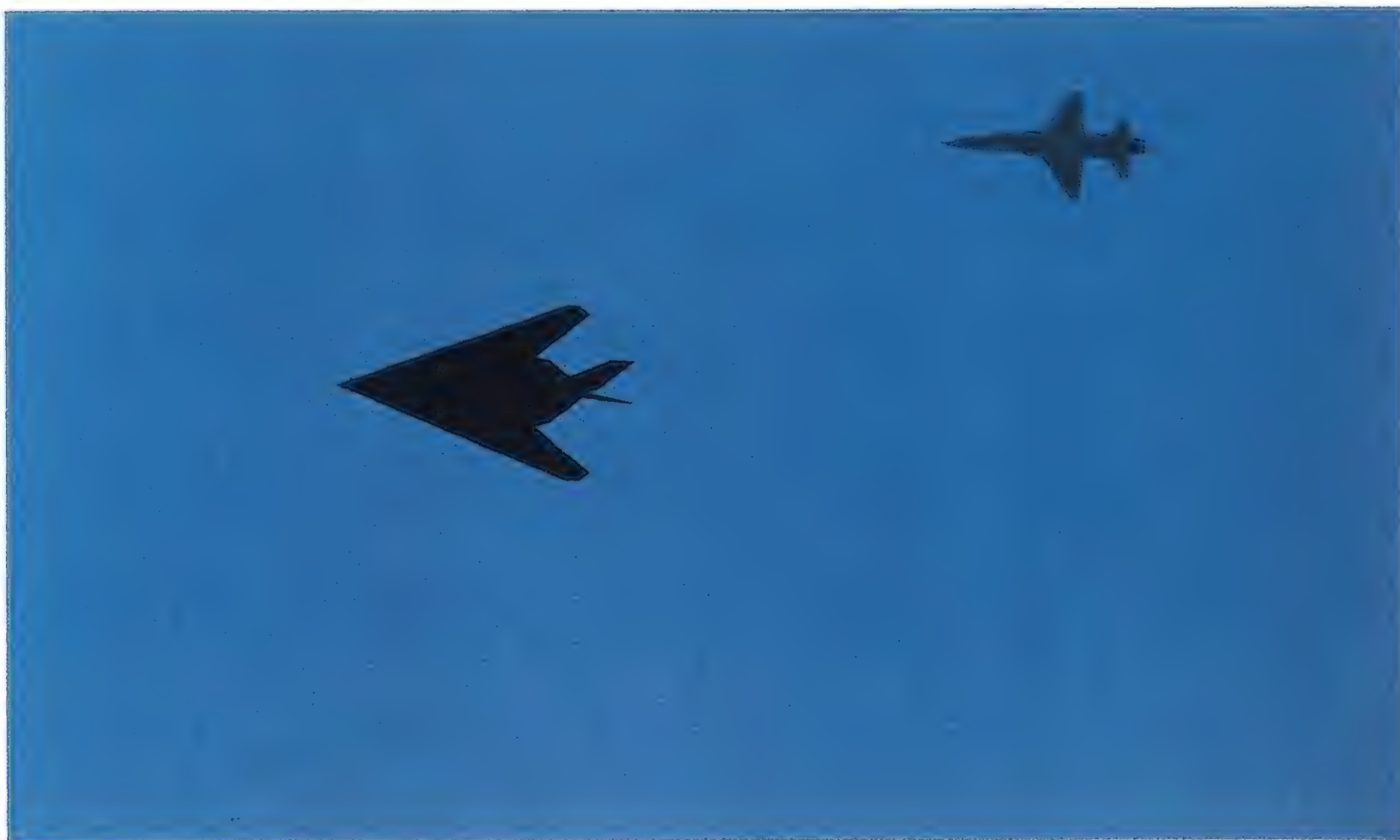
When he arrived in Tonopah, he pulled into a gas station and asked the attendant where he'd look if he wanted to see a stealth fighter. "Up," the attendant said. Within two hours one flew across town from north to south, and Aughenbaugh took home eight photos. Figuring that everyone in the Nevada desert must have photos of the F-117, he tossed his in a desk drawer.

Stealth stalkers may wait for hours in the Nevada desert...

"I couldn't believe that I was the only one who had pictures of this thing," he says. "I sat on them for a whole month."

Meanwhile, *Aviation Week* was starved for F-117 info. On May 1 it "primed the pump," says Michael Dornheim, the magazine's engineering editor, by running a cover photo of the F-117, taken by an astonished passerby as it flew over the Mojave Desert. "It was blown up ten million times," says Dornheim. "It really looked like a French Impressionist painting. But that let the world know *Av Week* was after the 117. So then all the stuff began to come out of the woodwork." Aughenbaugh sent his pictures, and the magazine ran three in the July 3 issue and one a week later. Goodall, who had made one fruitless journey to Tonopah nine months earlier, decided he needed to make another trip.

The manager of an Eden Prairie, Minnesota environmental monitoring



... before spotting an elusive F-117 (here with a T-38 flying chase).

equipment company and a walking encyclopedia of stealth, Goodall ranks himself among the world's top 100 aviation fanatics. His dream is to have a photo of every single aircraft the U.S. military has ever flown. His library contains over 50,000 photos plus 100,000 spares to trade with other enthusiasts. These are not just snapshots, mind you. "You have to be able to read the serial number," he says, "and you can't have the nose or tail cut off."

Goodall's special interest is "that spooky Lockheed program," a passion that was aroused in 1964, when he first saw the top-secret SR-71 Blackbird while stationed at Edwards Air Force Base as a communications specialist. "I told myself I was going to gather every bit of data humanly possible, within legal means, on that program," he says. "The same goes for the 117." Last September 11, two of his stealth pictures ran in *Aviation Week*.

Amateur photographers like Aughenbaugh and Goodall perform a valuable service for publications like *Aviation Week*. "I would have a difficult time going to my management and saying, 'I want to spend a week out in the desert, and most likely nothing will come of it, and please pay my expenses while I do it,'" says Dornheim. "You have to have someone who's impassioned enough to go

out and do that." In exchange, he says, "Goodall insists on a photo credit and an amount of money that indicates some level of respect. But it's not something that he's going to be making a living at."

* * *

For diehard sleuths, Tonopah is small potatoes compared to Groom Lake, a test facility also called "Dreamland" 80 miles southeast. "Groom Lake," says Goodall, "is one area where they have been authorized to use all force necessary, deadly force, to keep you out." It is the home, he thinks, of another covert airplane, named Aurora. "It's been mumbling around the aviation community now for six years," he says. "We believe it's a Mach 6 to Mach 8 airplane. It's been described as an X-15 on steroids—fat and chunky, with short stubby wings."

After a late dinner in Tonopah, Goodall and Andrews pile into their rental car and head toward Dreamland. The first time Goodall made this trip he was buzzed by an A-7 Corsair "doing 600 mph 30 feet off the deck" as he drove along a dirt road. "Scared the hell out of me," he says. Then he encountered a guard shack where "two very large NFL-linemen-type security guards came out. Both of them had M-16s with 30-round clips and 9-mm Berettas with the holster unclasp." It was the only time, he says, that he ever backed down in pursuit of his quarry.

This time Goodall and Andrews find a

different route. At Warm Springs, 49 miles from Tonopah, they take Highway 375 for one mile before turning south onto a dirt road. Fourteen miles from the highway and an additional 49 miles from civilization, they get a flat tire. While they put on the spare by the light of the moon, an F-117 flies overhead and a spectacular meteor shower lights the sky. Temporarily impeded but not discouraged, Goodall and Andrews head back to Tonopah, and early the next morning they're back out at the fence, waiting.

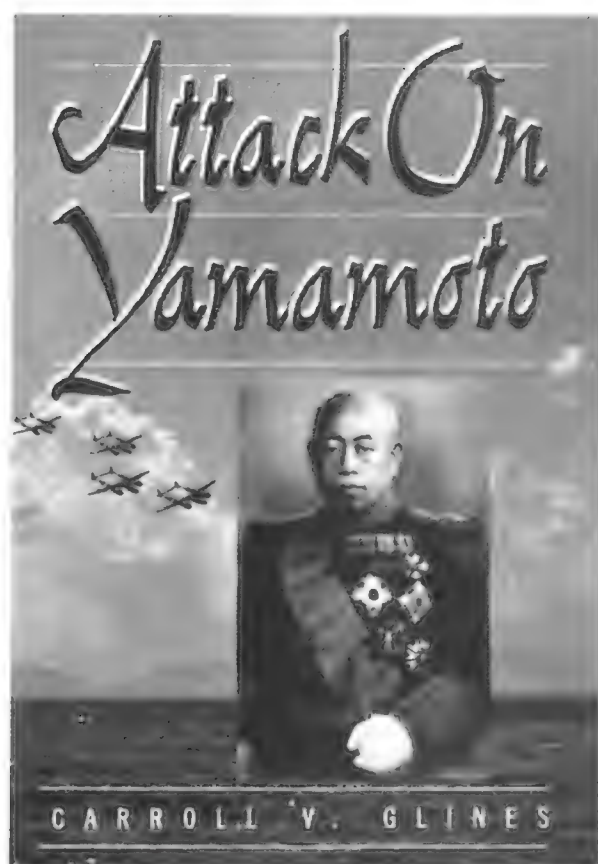
Here, on public property, they are prepared to challenge anyone who challenges them. "What they have out here is a very classified airplane," says Goodall, "a very secret program. But it's not the Air Force's airplane. It's owned by the taxpayers of the United States of America."

"This is my property," Andrews says, waving his arm back toward town. "That is also my property," he says, pointing to the land on the other side of the fence. "But this," he says, pointing down, "is the property I can walk on. We draw the line at doing anything illegal. But we are not afraid of going right up to that line—that's what we're doing at the fence, we're right at the limit."

If the military doesn't want these airplanes photographed, Goodall adds, it "better keep them out of the sky or fly them out of someplace I can't get to."

—Elaine de Man

Reviews(&Previews



Attack on Yamamoto by Carroll V. Glines. Orion Books, 1990. 240 pp., b&w photos, \$19.95 (hardbound).

The fatal ambush of Admiral Isoroku Yamamoto, Japan's top naval commander and strategist, is one of the most dramatic and fascinating episodes of World War II. Until now, Burke Davis' *Get Yamamoto* (Random House, 1969) was the most authoritative of the several accounts published on the incident, but Carroll Glines' penetrating study may well prove to be the final word. Glines, an aviation writer with a score of books to his credit, has done a first-rate job of retelling the story and examining the controversies surrounding it in the light of recent evidence.

Glines is primarily interested in settling the argument over who actually shot down the admiral. His approach is balanced and without the sensationalism that mars too many works of this sort. His sources—interviews, letters, reports, and other testimony and analyses—fully support his presentation.

Yamamoto was the architect of the

brilliant Pearl Harbor attack, the early victorious sweep of Japanese naval arms, and the ambitious but abortive Midway operation. In mid-April 1943, as commander-in-chief of the Combined Fleet, Yamamoto planned to make an inspection and morale-building visit of Japanese naval air bases in the northern Solomon Islands. A radio message containing his itinerary was intercepted and decoded by American naval intelligence, and a careful plan to shoot down the admiral's plane soon evolved. Yamamoto's death would be a stunning blow to the Japanese, depriving them of a key leader and inspirational hero.

On the morning of April 18, 1943, Yamamoto and his staff left Rabaul aboard two Betty bombers escorted by six Zero fighters. At the same time, 16 American P-38 Lightning fighters, their range extended by newly fitted auxiliary gas tanks, were flying a circuitous interception course from distant Guadalcanal. The two groups met just as Yamamoto was nearing his destination. A few minutes later both Bettys fell victim to the attacking Lightnings, and the admiral was killed.

The death of Yamamoto was more easily accomplished than the feat of determining who actually shot him down. For many years, the accepted view was that Army Air Forces Captain Thomas Lanphier, who led the "killer" section of the attacking P-38s, was the man responsible. But this was based largely on Lanphier's own self-serving testimony, and since then the arguments for crediting his wingman, Lieutenant Rex Barber, with the kill have grown increasingly persuasive.

Glines examines the evidence and the many investigations of the event in painstaking detail, and though he gives the reader sufficient information to draw his own conclusions, he comes down in favor of Barber.

Attack on Yamamoto also contains a useful discussion of the intelligence aspects of the operation: the Americans' success in breaking Japanese codes, the particular cryptographic effort that revealed Yamamoto's itinerary, and the fears that ambushing the admiral might reveal our

code breaking capabilities and thus deny us future intelligence. On the last point, Glines suggests without elaboration that those fears were needless. Indeed, we know from other sources that the Japanese refused to believe that their top naval code had been broken until many years after the war—by which time, of course, it was too late.

—Stanley L. Falk is former chief historian of the Air Force and author of several books on the World War II Pacific theater.

Planet Earth: The View From Space by D. James Baker. Harvard University Press, 1990. 192 pp., \$25 (hardbound).

The greening of our politics is once again in vogue. Not since the first Earth Day 20 years ago has so much attention been focused on environmental issues. At the same time, the Cold War's remarkable denouement is demanding a reassessment of federal spending and a redirection of the technical capabilities of the aerospace-military industry.

These interests are reflected in the Bush administration's most recent budget, which proposes a 57 percent increase across federal agencies in global environmental research programs and a 24 percent rise in the NASA budget—the two largest augmentations in an otherwise austere fiscal landscape. A large portion of this money is planned for enhancing a technology that serves both environmental research and aerospace technology: Earth observation satellite systems, also known as satellite remote sensing.

D. James Baker's book could thus hardly have a more timely release. *Planet Earth: The View From Space* presents a detailed exposition of satellite remote sensing. Satellite sensors now view Earth through the entire range of the electromagnetic spectrum, continually sending vast amounts of data on our environment to receiving stations. This vantage point has led to the establishment over the past decade of an interdisciplinary branch of research called Earth systems science.

The most exciting and challenging plan for studying the environment via remote sensing is NASA's proposed Mission to Planet Earth, an extensive network of satellites and ground-based data centers. Not surprisingly, the program is as expensive as it is ambitious. NASA expects to spend over \$30 billion on Mission to Planet Earth over the next two decades. Such a price tag inevitably produces vocal critics, but while Baker provides a detailed description of the Mission, he does not address the scientific and technological issues currently under heated debate.

Overall, though, *Planet Earth* provides a comprehensive introduction to Earth observation satellite technology for the uninitiated reader, as well as a useful reference source for the expert.

—Paul F. Uhler, a senior program officer at the National Academy of Sciences, writes frequently on satellite remote sensing.

RICK McCLEARY

Screaming Eagle: Memoirs of a B-17 Group Commander by Major General Dale O. Smith. Algonquin Books of Chapel Hill, 1990. 241 pp., b&w photos, \$18.95 (hardbound).

In *Screaming Eagle*, retired Major General Dale Smith has written an interesting, honest, and insightful memoir of his career as an air commander during World War II. Besides being a first-rate war story, it is also a human tale of men in combat—their fears and hopes, what makes them fight and what makes them fail.

Smith begins his story with an account of his days as a commander of a B-25 medium bomber squadron. Thrust into the disarray of the months after Pearl Harbor, he and his squadron were charged with patrolling off the Eastern Seaboard in search of enemy vessels. He recounts the hysteria aroused in December 1941 by reports that a Vichy French fleet, collaborators with Hitler, was approaching with an invasion force.

Airplanes and pilots were quickly marshalled to meet this threat, but, of course, the French never came.

The threat from German submarines was real, and became increasingly serious. Neither trained nor equipped for their sub-hunting mission, Smith's squadron nevertheless muddled on. After hundreds of flying hours in futile search, Smith finally sighted a submarine and almost sank it, only to discover it was one of ours.

The confusion and unpredictability of war emerges as one of the book's dominant themes. We see it in the unreliable weather that closed landing fields and caused crash landings and midair collisions, in the tired mechanics who installed an engine part incorrectly and caused an in-flight fire, and in the constant surprises of the enemy, who never fought at the time, place, or in the manner expected.

In November 1943 Smith was chosen to lead the hard-luck 384th Bomb Group, based at the English village of Grafton Underwood in Northamptonshire. The B-17 unit was reputed to be the worst in the Eighth Air Force, and it was Smith's task to whip the group into shape, restore its morale, and, more importantly, improve its performance. He began by setting strict discipline and training requirements. Although his initial attempts were met with apathy or outright resentment, Smith persevered, and within a year he had transformed the 384th into one of the top combat air units in Europe. By flying over two dozen combat missions, Smith won the respect, if not affection, of his men.

Screaming Eagle is also an intensely personal book that recounts the author's failing marriage to a woman worn down by a war that continually kept her man away. This is not an uncommon story, but it is one seldom told in a more objective and understanding manner.

Similarly, Smith explains the importance of regular mail deliveries, adequate food and housing, and, in the case of Grafton Underwood, the debilitating and depressing mud that covered all roads and sidewalks. While these things may seem unrelated to the war effort, in fact they had everything to do with it, because war is inherently psychological. Smith himself realized this when he noted a German fighter shadowing his formation as they returned from a mission over the Reich. The enemy pilot took no hostile action as he followed the bombers, and when he was over liberated France he bailed out. Smith knew then that the German morale was in an irreversible decline, and that the war had been won.

This book is well written, well conceived, and well balanced. The author is forthright and objective about his many mistakes and



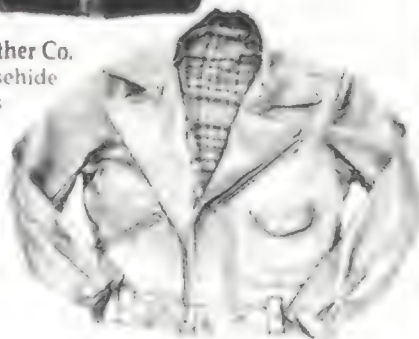
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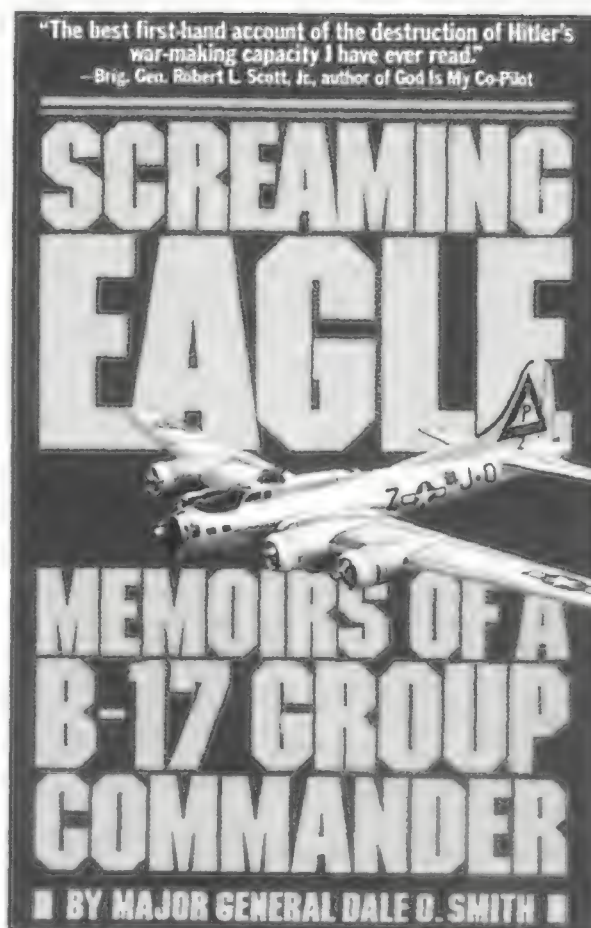


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—Lieutenant Colonel Phillip S. Meilinger
is an Air Force pilot currently assigned to
the Pentagon and author of Hoyt S.
Vandenberg: The Life of a General.

The Battle of Britain by Richard
Townshend Bickers. Prentice Hall Press,
1990. 208 pp., color and b&w photos and
illustrations, \$29.95 (hardbound).

As might have been expected in its 50th anniversary year, the Battle of Britain has already provided the theme for a multitude of recently published books. This latest, *The Battle of Britain*, has been assembled by Royal Air Force airman Richard Townshend Bickers, who has written several of the book's chapters.

Inside, the list of distinguished pilots and aviation writers who have contributed chapters makes one's mouth water with expectation. The pages are profusely illustrated with lots of well-known photographs but just as many that are new. All are splendidly reproduced. Likewise, the book's maps are admirably executed. The delicately colored battle maps, drawn to indicate the three dimensions of the air battles, are particularly commendable in clarifying some confusing information.

While the framework is pleasing, the substance, however, is often disappointing. It is almost inevitable that a volume containing the work of several authors looking from different angles at the same subject will be somewhat patchy and repetitive.

The most scrumptious parts of the text are undeniably good. Sir Hugh Dundas' "Battle Summary" chapter and Bickers' "Battle Diary" are almost worth the cover price on their own. Indeed, taken individually, the offerings of the



Unconventional Aircraft by Peter M. Bowers. Tab Books, 1990 (second edition).
324 pp., b&w photos, \$19.95 (paperback).

Flip through these pages and one can't help but admire the spirit behind these inventions—those that advanced aviation, those (such as the Taylor Aerocar, above) that never quite caught on, and those that, let's face it, never stood a chance. Brief but thorough histories of each aircraft and plentiful black-and-white photos make for fun browsing.

THE BATTLE of BRITAIN

The greatest battle in the history of air warfare
Richard Barnbrook Dickson



Foreword by
Air Marshal Sir Denis Courtney MBE, CBE, DSO, DFC, AFC

contributing authors might be seen as more than adequate in dealing with their subjects. Unfortunately, the parts do not produce a satisfying whole, and, despite the chapters devoted to the Luftwaffe, the end result feels decidedly lopsided.

Fifty years after the event, it is surely not necessary to adopt a moralizing tone: "the British were in the right" and "the British do not dramatize." (Really? What about Churchill?) Arrogance and pomposity are equally out of place: "The Luftwaffe's leadership at all levels was inferior to the RAF's" (What about Molders and Galland?); "the mouth-organ may have been acceptable in a German officers' mess; but not a British one"; and, in a comment on a German pilot's account of a bounced Spitfire diving away to escape, "One has to conclude that the Spitfire had run out of ammunition."

Whatever arguments may be advanced to refute those opinions, there can be no excuse for such an apparently ambitious book to be so riddled with contradictions, confusions, omissions, presumptions, and misunderstandings, as well as a grating sloppiness in detail that appears on almost every page. Among such minor but irritating errors, a Dornier 17Z is shown "separated from its formation" even though another Do17Z can be seen in the picture. Likewise, 15 Blenheims of "109 Squadron" take off, but only one of "107 Squadron" returns.

For all its promise and visual appeal, this is not a book for those in search of accuracy or dispassionate reporting. To paraphrase a well-known poem, when it is good, it is very, very good, but when it is bad it is horrid.

—Air Vice Marshal Ron Dick (Royal Air Force, retired) is the author of this issue's "Sunset on Adlertag."

Men in the Air: The Best Flight Stories of All Time From Greek Mythology to the Space Age edited by Brandt Aymar. Crown, 1990. 557 pp., \$24.95 (hardbound).

Enthusiasts should keep this entertaining anthology next to the bed so they can prime their dreams by reading a selection before drifting off to sleep. At a chapter per evening, *Men in the Air* will provide more than two months of enjoyment.

Editor Brandt Aymar has included both fiction and nonfiction, grouped by topic and arranged chronologically. Nearly every significant event or era in flight's development is covered, and nearly everyone will find his or her favorite subject.

Airplane tales start with the Wright brothers' own story of their 1903 flight at Kitty Hawk. Student pilots will enjoy "The Flight to East Hampton," the story of a youngster who takes off after "learning" to fly by studying maps and a Cessna manual.

The largest section, "Air Battles," contains sketches of the world's most prominent combat pilots, from Eddie Rickenbacker to the remarkable Erich Hartmann, "the Blond Knight of Germany," whose 352 confirmed victories in World War II make him the ace of aces.

Readers will also find Saint-Exupéry's thoughts on weather and the unique relationship between pilots and the elements; classic and contemporary aircraft stories, from Ernest K. Gann's *Fate Is the Hunter* to *The Right Stuff*'s chapter on Chuck Yeager's flight beyond the sound barrier; and accounts of space milestones like John Glenn's flights and Neil Armstrong's first steps on the moon.

Its title notwithstanding, *Men in the Air* also includes works on women in aviation, but they are lumped together in the back of the book, regardless of their content. Another minor weakness is the lack of introductions to help put the excerpts in perspective—a bigger problem with some stories than others. The story of the *Hindenburg*'s fiery destruction, for example, begins: "The Reederei, preparing a short news bulletin to this effect, notified the Deutsche Nachrichtenbüro, the official government news agency."

Nonetheless, this fine collection will bring hours of enjoyment to fliers and flight aficionados who find themselves earthbound. *Men in the Air* is the next best thing to being airborne.

—Jack Satterfield works for a New York public relations firm. A Navy Reservist and pilot, he has written on military and other topics for several publications.

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Three Republics (USSR) September
9-23: Russia, Estonia, Georgia.

English Canals September 11-23.

Yugoslavia September 11-23.

Spain September 11-23.

Glasnost and Perestroika (USSR)
September 12-23: Study current affairs
with Soviet scholars.

Switzerland by Train September 12-24.

Ireland Walk September 18-28.

Rhône Cruise September 18-October 2:
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**Modern Masters in the South of
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Brazil October 1-18.

Cotswold Walks October 4-16.

**Castles and Gardens of Czechoslo-
vakia and Hungary**
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Turkey and Greece October 10-23:
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October 11-31: Hong Kong, Bali.

Australia October 13-30.

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**Folk Art and Celebrations of Colonial
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Bermuda November 8-12 or February
14-18: Enjoy the island's cultural
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18: Annapolis. Learn at the Smithsoni-
an's Environmental Research Center.

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October 14-18: Stay in historic Annapo-
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Edwards Park.

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Credits

Lights, Camera, History! Lee Battaglia is the picture editor of *Air & Space/Smithsonian*.

Up Over Down Under. Edwards Park is a frequent contributor to *Air & Space/Smithsonian*.

Ensign Nolo, USN. Bill Wagstaff's article "A Spaceship Named Orion" appeared in the October/November 1988 issue.

NATO's Noise Problem. An Air Force brat, William Triplett lived for a time at Andrews Air Force Base in Camp Springs, Maryland, where he was subjected to many F-4 Phantom takeoffs and landings. His hearing, however, is fine.

Two Faces of Catastrophe. Wayne Biddle, a Washington, D.C.-based journalist, is writing a history of the aerospace weapons industry to be published next year by Simon and Schuster.

Sunset on Adlertag. Ron Dick retired from the Royal Air Force with the rank of Air Vice Marshal and is now in his second

year as an International Fellow at the National Air and Space Museum.

Nader's Air Raiders. David Savold is an associate editor at *Air & Space/Smithsonian*.

To Spear a Comet. Formerly managing editor of *Astronomy*, Stephen Cole is now managing editor of *Eos*, the American Geophysical Union's weekly newspaper.

The Great Alaskan Fishlift. Freelance writer Elaine de Man's story is based on her observations of the 1989 salmon harvest—Alaska's biggest on record. She is also the author of "Shooting the Stealth," this issue's Groundling's Notebook.

Kapustin Yar Diary. Gregg Herken wrote "The Flying Crowbar," which appeared in the April/May 1990 issue.

Relic From the Cold War. Bob McCafferty is a Fair Oaks, California-based writer and photographer. He is a veteran of the Strategic Air Command, where he flew only computers.

Calendar

August 4 & 5

Hoosier Hoopla Airshow. Gary Regional Airport, Gary, IN, (219) 944-9984.

August 6-10

Society of Flight Test Engineers Symposium. Hyatt Regency Hotel, Anaheim, CA, (213) 593-2709.

August 11 & 12

Beaver County Airshow. Beaver County Airport, Chippewa, PA, (412) 846-9922.

August 18 & 19

Prairie Aviation Museum Air Show. Bloomington-Normal Airport, Bloomington, IL, (309) 663-7632.

Northeast Flight 90 Airshow. Blue Angels, Harrier. Schenectady County Airport, NY, (518) 382-0041.

August 23-26

Sentimental Journey to Cub Haven Fly-In. Nightly corn roasts, daily fly-overs, aircraft judging, and hot-air balloon rides. William T. Piper Memorial Airport, Lock Haven, PA, (717) 893-4207.

September 7-9

Greenville Fly-In. Moosehead Lake, Greenville, ME, (207) 695-2702.

September 8

Airline Collectibles Show and Sale. Sponsored by Tri-State Airline Historical Society. Buy, sell, and trade airline memorabilia. Vista Hotel, Newark Airport, Elizabeth, NJ, (914) 965-3010.

September 8 & 9

Mid-Eastern Regional Fly-In. Marion Municipal Airport, Marion, OH, (513) 849-9455.

September 24-28

U.S. National Aerobatics Championship. Grayson County Airport, Denison, TX, (214) 465-1551.

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"The Satellite Sky" Update/19

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches 90 to 300 MILES

 **Cosmos 2072**
 4-13-90 TT

 **Cosmos 2075**
 4-25-90 PL

 **Cosmos 2077**
 5-7-90 PL

 **Cosmos 2078**
 5-15-90 TT

 **Kristall**
 5-31-90 TT

 **Resurs-F6**
 5-29-90 PL

300 to 630 MILES

 **Cosmos 2074**
 4-20-90 PL

 **Cosmos 2082**
 5-22-90 TT

 **Hubble ST**
 4-24-90 KSC


 **Macrats (2)**
 5-9-90 VAFB

 **Roentgen**
 5-29-90 CAC


6,200 to 13,700 MILES


 **Cosmos 2079-81**
 5-19-90 TT


21,750 to 22,370 MILES


 **Palapa B-2R**
 4-13-90 CAC

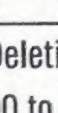
Additional satellites
300 to 630 MILES

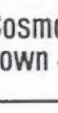
 **Microsat A**
 1-21-90 KOU

 **Microsat B**
 1-21-90 KOU

 **Microsat C**
 1-21-90 KOU

 **Microsat D**
 1-21-90 KOU

 **Uosat D**
 1-21-90 KOU

 **Uosat E**
 1-21-90 KOU

Deletions

90 to 300 MILES

Cosmos 2062 down 4-5-90
Progress M-3 down 4-28-90

Launched but not in orbit

90 to 300 MILES

Cosmos 2073 USSR	4-17-90	down 4-28-90
earth sensors		
Foton 3 USSR	4-11-90	down 4-27-90
research		
Progress 42 USSR	5-5-90	down 5-27-90
research		

300 to 630 MILES

STS-31 US 4-24-90 down 4-29-90
 research

Forecast

In the Wings...

Battle of Britain III: The Wizards' War. While the Royal Air Force was fighting the Luftwaffe in the skies, radar stations on the ground were playing a vital role of their own. But it took some time to get the bugs out.

X-ray Astronomy. Many scoffed when a small group of astronomers suggested looking for X-ray sources emanating from space. The scoffing soon stopped as X-ray astronomy began revealing new horizons in space science.

The Blackbird Goes Out to Pasture. When the SR-71 retired, it went out by setting yet another speed record. Even mothballed, this airplane still astounds.

Space Shuttle Pit Stop. When a shuttle returns from orbit, its technical crew has a lot more to do than rotate the tires and change the oil.

The Mars Transit System. Apollo astronaut Buzz Aldrin and co-author Malcolm McConnell discuss one way to make Mars a regular stop for travelers from Earth.

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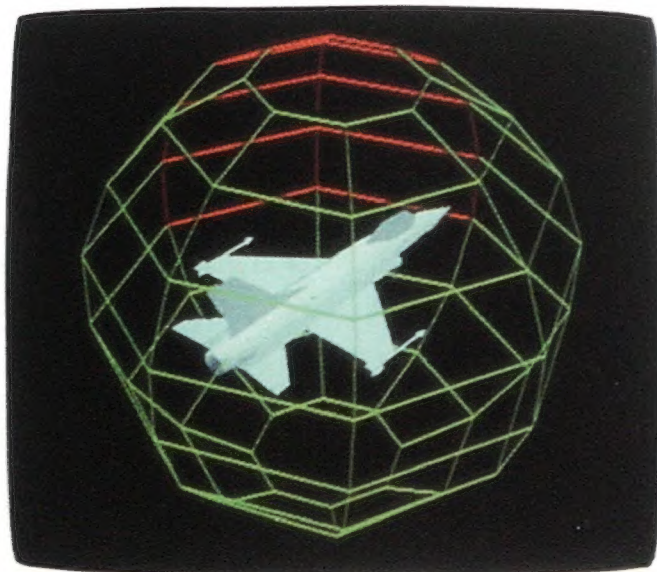
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